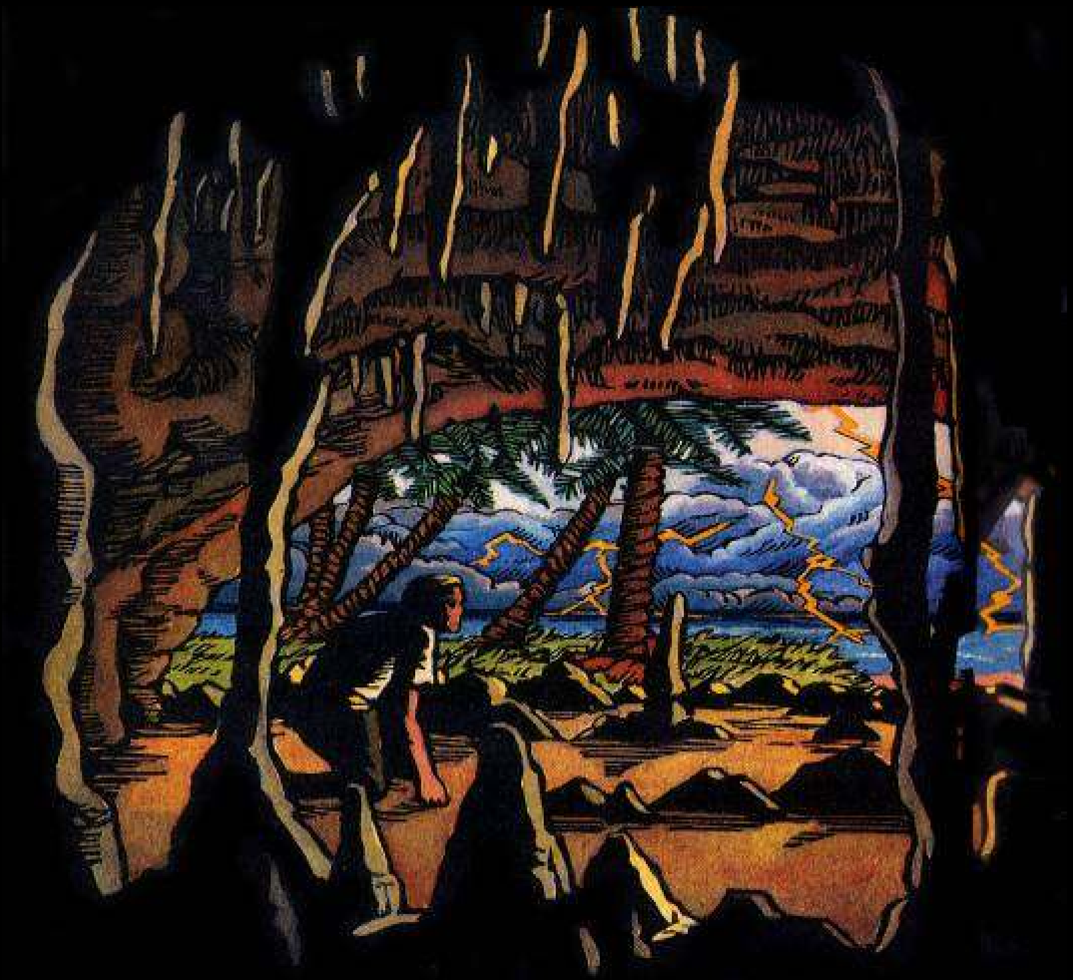
Underground Rivers

from the River Styx
to the Rio San Buenaventura
with occasional diversions



Richard J Heggen

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Updates at http://www.unm.edu/~rheggen/UndergroundRivers.html

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http://www.unm.edu/~rheggen/UndergroundRivers.htm

Cover adapted from Journey to the Center of the Earth, Reader's Digest edition (1992), illustrated by Lars Hokanson.

PROLOG

Learning of my topic, underground rivers, my sister recalled that long ago I'd taught her to draw underground worlds in ant-farm perspective. I'd forgotten my artistry, but once reminded, my subterranean creationism came to memory -- tunnels and caves in which the likes of Happy, Grumpy, Dopey, Doc, Sneezy, Sleepy and Bashful might chorus, "Hi ho, hi ho. It's off to work we go," as they march to the diamond mine. The enterprise of course needed a few waterways? And there'd be forts and secret hideouts. Unencumbered minds are knowledgeable of such.

Grade schoolers know of the hydrologic cycle, a wheel of evaporation, clouds, rainfall and rivers back to the sea. Advanced textbooks add infiltration, a groundwater reserve, seepage to springs and a route passing soil water to vegetation which transpires vapor back to the atmosphere, often citing Leonardo da Vinci as the discoverer of it all. He wasn't, but indeed he was on the right track if we limit our look to a favorable few of his backwards-scribed thoughts.

Unencumbered by criteria of scientific rigor, Leonardo simply recorded his ponderings, what he believed he saw. And as with most of us, such insight may wander. While he envisioned a hydrologic cycle as we now know it, he likewise conceived of a subterranean cycle spinning in reverse, one in which water flows from sea to mountain. A divergent mind is free to venture.

I, on the other hand, was an engineering academic employing physical principals (just three will usually do, thank you) to compute such fluid behaviors as streamline direction. Water is obligingly law abiding, predictable even in its turbulence. One advances in the direction one expects to travel. There should be but a single streamline in a journal article.

Leonardo and I would thus have had little in common, other than that he might have appreciated my childhood art, and I, his sketches of cascading waters.

Perhaps through erroneous cataloging did The Hydrologic Cycle and the Wisdom of God, A Theme in Geoteleology (1979) by Yi-Fu Tuan end up in the University of New Mexico Centennial Science and Engineering Library. Curiosity led me to pull the slight volume from the shelf where it languished -- long languished, according to the due-date stamps -- amidst weighty references on such topics as vadose flow and my interest at the time, kinematic waves.

"Geo," engineers know, pertains to the earth, but "teleology" wasn't in my vocabulary. It's the philosophical study of design and purpose. Tuan's book dealt with how 17th-century Christianity came to presume hydrologic vindication in the works of Newton. Not a reference on kinematic waves, for sure, but I was enchanted by the period woodcuts.

Tuan's work -- not a quick read for one like me -- revealed to me that the subject of hydrology -- a field in which I'd thought myself reasonably versed -- engendered streamlines in a myriad of directions, streamlines through a world in which like Leonardo's, ideas run freer.

I thus return to my juvenile sketches of underground wonders. It's not the Seven Dwarfs' gold I pursue, but the subterranean streams that they encounter, rivers in which streamlines diverge.

Regarding the seven dwarfs, not until much later would I discover that Disney's Snow White (1937) actually contains an underground river. See Chapter 23, Girls, Too! I shouldn't have been surprised, as such rivers are indeed everywhere.

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INTRODUCTION

Hydrology is the study of the occurrence, distribution, movement and properties of the waters of the earth. As water impacts so many aspects of science, we have engineering hydrology, geohydrology, hydrogeology, geographical hydrology, environmental hydrology, fluvial geomorphology and the list goes on.

But hydrology is more than science; it's the study of our relationship to water. We draw water to drink, of course, but we as well draw upon water for intellectual sustenance. What would art be without paintings of seascapes? What would poetry be without stream banks upon which to sit and read? What would adventure be without uncharted oceans? Huckleberry Finn is about the Mississippi and in turn, the river is about the boy.

Consider the academic departments at a university and with each, there's a tie to the words "underground river." We engineers relish in the fluid mechanics aspect. Philosophers know of the mythical rivers in Greek classics. Political scientists speak of underground rivers of social change. Art historians recognize Charon, the wizened boatman, in millennia of paintings.

What would be our awareness of the unseen without allusions to subterranean streams?

And why be faint in our quest? We shall follow underground rivers wherever they lead through Western civilization.

Our journey won't be technical, though we will encounter occasional decimal numbers, a few lines of chemistry and a bit of physics. But we will also encounter (but only briefly, rest assured) the likes of James Joyce. When we tire of literature, we can collect stamps. We'll add "achluohydrophobia" to our vocabulary. We'll be the life of the party, sharing really-interesting facts of history and geography, though we might not get invited to the next party.

Our journey's not about ports, but about pathways. We will travel underground waterways that stray across the boundaries of co-existing, sometimes contrasting, perspectives. As do above-ground rivers, our subterranean journey may meander, diverge and reconnect. If a particular segment fails to catch our fancy, we're free to portage onward and drift back as we like.

No serious scholar would so risk his or her credibility, of course, but the rest of us have less to risk.

Models

Before we embark, however, we need an underlying concept, that of modeling.

> A model is an expression of something we wish to understand in terms of something we think we do understand.

To illustrate how a model works, we'll ask a basic question,

> Why do underground rivers do what they do?

Consider modeling's two definitional phrases: "something we wish to understand" and "something we think we do understand." Modeling can lead us in odd ways when either is astray.

The "we wish to understand" introduces subjectivity. What sort of behavior of underground rivers piques our curiosity? The velocity? The direction? For illustrative purpose, we'll say that our interest is the mechanism that transports water from the sea to an upland spring. If we're misinformed regarding the river in the first place, the answers may be legion and their content most imaginative, but for that we must wait to Chapter 8, Subterranean Engines.

The "something we think we think we do understand" is as open ended as our capacity to host ideas. As applied to an underground river, mechanical engineers, for example, might turn to laws of thermodynamics. Geographers might prefer a topographic map. Scholars of the humanities might look to literary portrayal.

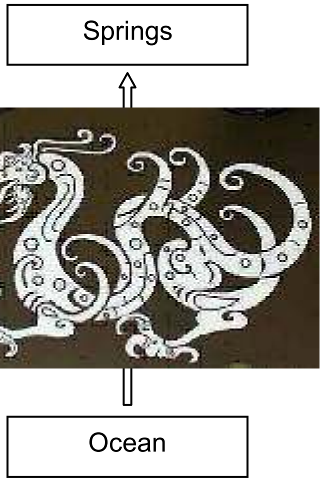
Science involves the perception of patterns that exist. Superstition involves the perception of patterns that do not. We tend to be good at perceiving patterns, but weak in discerning the veracity aspect. Science and superstition thus aren't as distinct as we prefer to believe.

In that light, let's imagine that Hollywood has recently entertained us with a blockbuster involving dragons. The animated creatures seemed, in fact, quite alive. Our hypothesis is that subterranean water is propelled from sea to springhead by a dutifully-belching reptile. We prefer our dragon theory over, say, one utilizing a hose, because in blasting the water upward, our great beast also consumes the salt.

To wit,

We wish to explain springflow.
We do so by means of a dragon.

We'll express our model as a graphic.



The boxes represent water; the upward arrow, transport. What's between is the means. It might seem silly to bother with a drawing, but we may be thankful for such visuals in Chapter 8.

An errant hypothesis can be a useful step in the scientific process. A dragon would tire of a salt diet and our sonar device yields no belching. After a bit of reflection and observation, we'll perhaps dismiss the dragon model. We'd prefer a mechanism more satisfactory in terms of realism, precision, generality and/or intellectual manipulability.

How about, say, we replace the dragon with a giant magnet? After all, everyone knows that there's iron in the earth.

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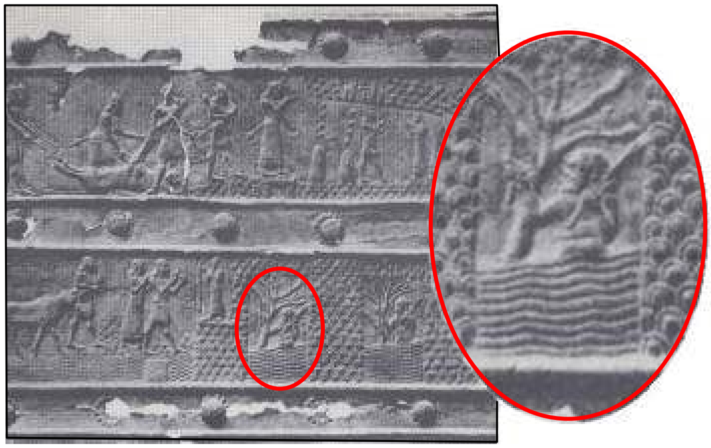
Although the contents intertwine, the designations at the right may assist in plotting the journey.

CHAPTER 1

GREEK MYTHOLOGY

We begin our underground river journey with Homer (c. 800 BC), whose works -- as we will come to see -- yet underpin Western culture.

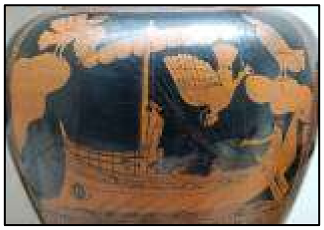


Let us pause, however, to recognize that the Greeks were themselves drawing upon other civilizations.

To the right we have from the British Museum a bronze Babylonian panel showing a visit to caves near the source of the Tigris in about 852 BC.

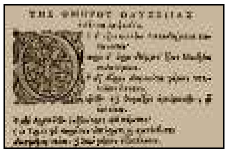
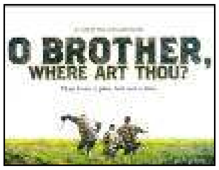
We see stalagmites and, in the lower portion, an underground river. We'll see much more of the boatman in chapters to come.

To ancient Greeks, the underworld was not an abstraction. Their underworld -- or least its upper layer -- was more than 10,000 limestone caverns. And where there's limestone, there's been (and still may be) water. What humans see, they strive to explain.



Homer's Iliad and Odyssey are archetypal folkloric epics of human quest. The Iliad describes the conclusion of the Trojan War and the Odyssey tells of Odysseus' (Ulysses in Latin) ten-year homeward journey. Sailing his bark into the dark unknown and undertaking a series of ordeals, the hero re-emerges as a fuller person. Odysseus and the Sirens are illustrated on the 2500-year old vase.

Those unfamiliar with the saga can rent the video. While director Joel Cohen admits only to having read the Classic Comics Odyssey, his and his brother Ethan's film O Brother, Where Art Thou? (2000) faithfully replicates the tale. Following are a few correspondences.

	 Odyssey (c. 855 BC)	 O BROTHER, WHERE ART THOU?
Author	Homer	Joel/Ethan Cohen
Protagonist	Odysseus	Everett Ulysses McGill
Setting	Mythical Mediterranean, Mythical times	Mississippi, 1920s
Opening	*Tell me, O muse, of that ingenious hero who travelled far and wide after he had sacked the famous town of Troy.*	*Sing in me, and through me tell the story of that man skilled in all the ways of contending a wanderer, harried for years on end.*
Characters	Lotus Eaters Cyclops Sirens	Baptists Bible salesman Washerwomen
Rivers	Acheron Cocytus Styx Lethe Pyriphlegethon	A river is involved at either end -- the baptism and the flooding.

We'll make similar Odyssean comparisons in chapters to come. One can't keep a good story down.

As enduring as the saga's hero are the deities of the world through which he journeyed. To the right are several of the many Greek gods, along with their Romanized names. Though we today may be only vaguely familiar with the particular legends, the gods of Homer live on in our common references.

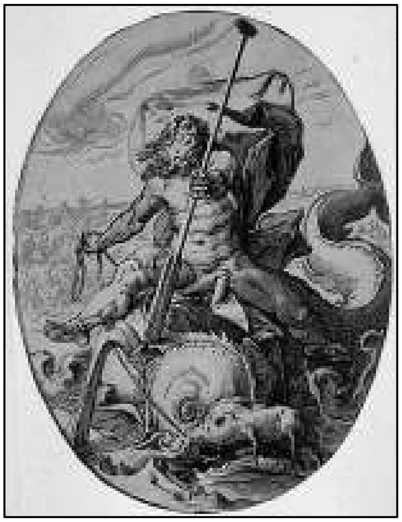
In addition to committing to written form the even-then ancient mythology, Homer draws upon cultural memories of Bronze Age seamen who sailed to where the “Ocean River” flows.

Greek	Roman
Aphrodite	Venus
Apollo	Apollo
Ares	Mars
Hermes	Mercury
Poseidon	Neptune
Zeus	Jupiter
Eros	Cupid
Heracles	Hercules
Atlas	Atlas
Cronus	Saturn
Hades	Pluto

Oceanus, the Ocean River

Oceanus was both a god and a water body. As the former, Oceanus was the eldest of the twelve Titans (the race from which sprung humans), Oceanus did not join the dispossessed Titans against the Olympians, but instead withdrew from the struggle doomed by Zeus’ thunderbolts.

With his sister Tethys, Oceanus fathered some three dozen gods, 3000 rivers and 3000 ocean nymphs.



Oceanus was represented as an old man of noble presence and benevolent expression, with the horns of an ox or bull, sometimes crab claws on his head, a long beard, a muscular upper body and the lower torso of a serpent encircling the earth. His attributes included a pitcher, cornucopia, rushes, marine creatures and a scepter.

As a water body, Oceanus was the Atlantic Ocean, but not the geographically-bounded sea we know today. Oceanus was a river running around and the earth, which in turn was believed to be a flat disk called Gaea, a derivative of a prehistoric Egyptian/Babylonian account in which the god Marduk piled dirt on a rush mat floating on primordial water. The Nile was thought to be directly connected. The sun and moon rise from and descend into this stream and only the Great Bear remains above the waters.

From the Iliad,

> *Deep flowing Oceanus, from which flow all rivers and every sea and all springs and deep wells. Never mingling with the sea which it encloses, it has neither source nor mouth.*
>
> *With Jove neither does King Achelous fight nor does the mighty strength of the deep-flowing Oceanus, from which flow all rivers and every sea and all springs and deep wells.*

On Oceanus' shores dwell the minute Pygmies. On the southern banks lies Elysian where the "blameless Aethiopians" dwell in perfect happiness.

Beyond the west lies the realm of eternal and infernal darkness where vegetation is black poplars, fruitless willows and funerary asphodel. “The Afterworld,” says Circe to Odysseus “lies at the extreme of the earth, beyond the vast Ocean.”

As traders continued to find inhabited and fruited land where Oceanus’ desolation would have been expected, however, an adjustment was called for. Connection to the infernal region must be via another Oceanic link, perhaps one closer to home, perhaps even in Arcadia where watery caves abound. (We will see why this is so in later chapters, but we don't want to muddle Hellenist thought with geologic digression.)

And thus came to be known the five subterranean rivers, mythical waters, we'd like to say, but like the gods, still very much alive.

The Cocytus, the river of lamentation

> The dead who can not pay Charon (whom we will meet shortly) must wander its banks forever.

The Lethe, the river of forgetfulness

> The Lethe passes the extremity of the Elysian Fields. Those who drink of this stream forget the past. The Eridanus (Po) was said to spring from the Elysian Fields, where Aeneas saw it flowing. As later expressed by the Roman poet Marcus Annaeus Lucanus in his epic "Pharsalia,"
>
> > *Here Lethe's streams, from secret springs below*
> > *Rise to the light; here heavily, and slow,*
> > *The silent, dull, forgetful waters flow*

The Acheron, the river of woe

> Myths tend to be inconsistent regarding geography. Homer described the Acheron as the channel into which the Pyriphlegethon and Cocytus empty. Virgil (the Roman Encyclopedist,

Chapter 3) described the Acheron as the source of the Styx and Cocytus. And yet others claimed the Acheron to be a branch of the Styx.

According to others, the Acheron, turbid with mud, flows from desert places to

The Stygian marsh, or
Acherusian Lake where the souls remain until they are reborn, or perhaps,
The Grove of Persephone, the wife of Hades, whose kingdom lies further downstream.

The Styx, the river of hate, the river of unbreakable oath

The poet Hesiod (c. 750 BC) considered Styx to be the daughter of Oceanus. Comprising one-tenth the volume of its parent, the Styx flows out of a rock and into a mass of broken rock where it encircles the underworld nine times. In other accounts, the Styx passes around Acherusian Lake and becomes the Cocytus.

We'll have more to say about the River Styx in Chapter 32, To Cross the Stys, and in Chapter 63, The Law of Subterranean Streams.

The Pyriphlegethon, the river of fire

Around the underworld runs a fence of bronze beyond which night spreads in triple line to the Pyriphlegethon, a torrent of lava and clashing boulders. The Pyriphlegethon approaches the edge of boiling Lake Acherusia, but does not mingle. Souls remain here until they are reborn.

A handy mnemonic: the first letters of the five rivers spell CLASP. As we'll be encountering them over and over, it may help speed the recognition.

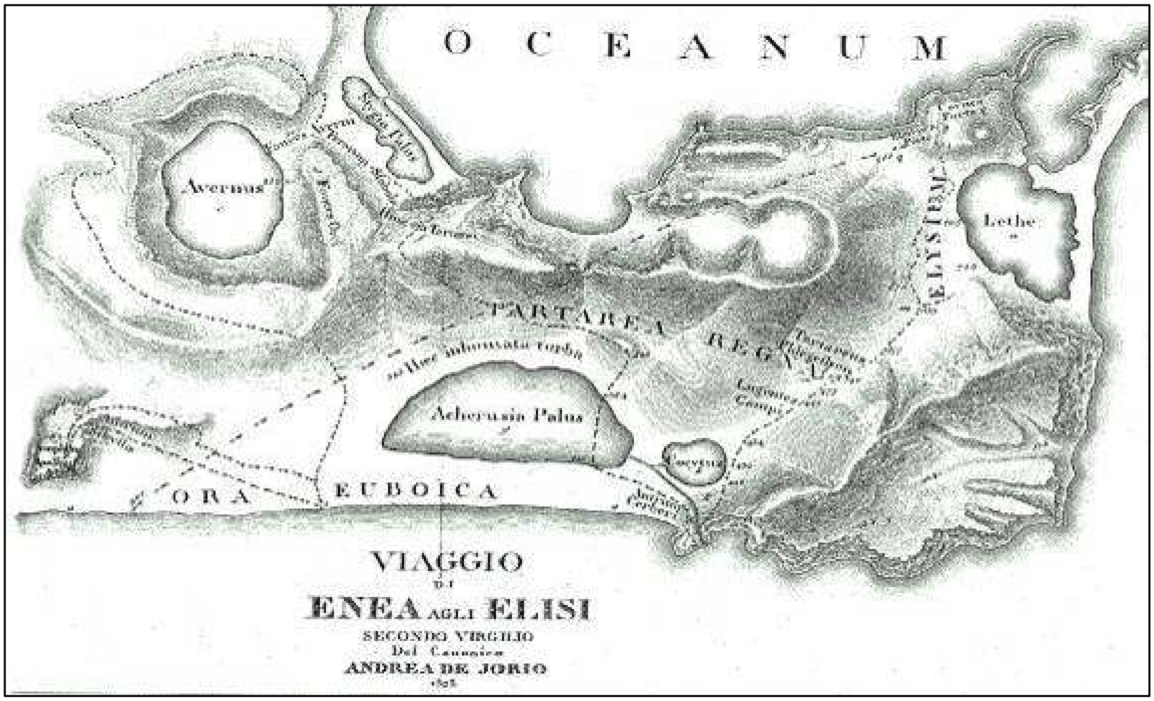
The five rivers oscillate from one side of the underworld to the other. As they surge to and fro, surficial waters flow into and out of chasms, generating the sea's tides.

Tartarus, the lowest abyss beneath the earth, from where all waters originate and to where all waters return, is as far distant from earth as earth is from the sky. An anvil falling down from heaven would take ten days to reach the ground. An anvil falling from earth to Tartarus would take ten days more. Homer portrayed Tartarus as an ominous realm inhabited by shadows. In the dank, gloomy pit below the roots of the earth and sea, the dead fade into nothingness. . Nothing is real; existence itself is but a miserable illusion.

(Note the term "abyss," a noun more ominous than "hole" or "cave." We'll deal with the idea of a foreboding cavity within the earth's interior in many chapters to come.)

In myth closer to the present, Tartarus becomes Hades, a place of punishment for mortal sinners, antithetic to the blessed afterlife on the Elysium Fields.

Recalling the disagreement about the Acheron, we'll view the 19th-century map below as someone's best guess. Pertinent names are overtyped for easier identification.



We will remap today's superterranean Arcadian watershed in Chapter 28.

To enter Tartarus, souls must cross a river, but which one? Early Greeks thought it to be the Acheron. The Romans said it to be the River Styx or Lake Acherusia.

The Acheron	Both the Acheron and the Styx	The Styx
Pindar (ca. 522–443 BC) Aeschylus (c. 525-455 BC) Euripides (ca. 480–406 BC) Plato (428-348 BC) Callimachus (ca. 310-240 BC) Pausanias (110-180) Dante (1265-1321)	Virgil (70-19 BC)	Propertius (ca. 45-15 BC) Ovid (43 BC-17 AD) Statius (ca. 45-96 AD)

We will meet many of the above in later chapters.

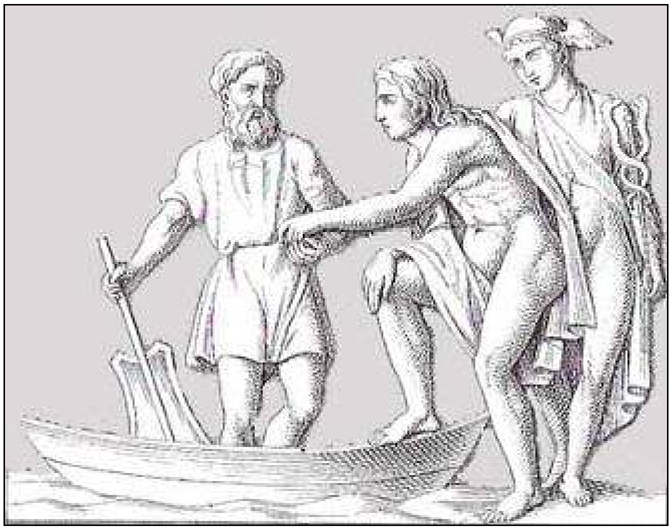
To muddle the lore a bit more, some acounts thought the psychopomp -- a general term for a guide of the dead -- to be the god Phlegyas, but in the overwhelming majority, it's Charon.

In deference to the lore that's todays standard, that of Virgil, we will call it the Styx.

Boatman's Fee
2 obols

To this purpose, the aged and avaricious boatman, Charon, ferries those upon whose lips has been placed the two-obol fare at cremation. As the coin was worth less than a modern American dollar, the poor were not excluded; at issue was preparation of the corps.

As fares for underground river passage have carried over into modern life, we'll yse the box format to note prices as we come upon them throughout the remainder of our journey.



Charon receives a fare. Hermes stands to the right.

A sarcophagus depicting Charon

The fifth century BC Greek tragedy "Aeschylus, Seven against Thebes" speaks of the voyage.

> *But sail upon the wind of lamentation, my friends, and about your head row with your hands' rapid stroke in conveyance of the dead, that stroke which always causes the sacred slack-sailed, black-clothed ship* [of Charon] *to pass over Acheron to the unseen land where Apollo does not walk, the sunless land that receives all men.*

In the course of Aeneas's descent to the underworld after the Cumaean Sibyl has directed him to retrieve the golden bough, Virgil's Aeneid (a Roman retelling of the Greek tale) describes the ferryman.

> *From here* [the path to the underworld] *is the road that leads to the dismal waters of Acheron. Here a whirlpool boils with mud and immense swirlings of water, spouting up the slimy sand of Cocytus. A dreadful ferryman looks after the river crossing, Charon, appalling filthy he is, with a bush of unkempt white beard upon his chin, with eyes like jets of fire; and a dirty cloak draggles down, knotted about his shoulders. He poles the boat, he looks after the sails, he is all the crew of that rust-colored ferry which takes the dead across.*

Or in a more poetic translation.

> *There Chairon stands, who rules the dreary coast*
> *A sordid god: down from his hairy chin*
> *A length of beard descends, uncombed, unclean;*
> *His eyes, like hollow furnaces on fire;*
> *A girdle, foul with grease, binds his obscene attire.*

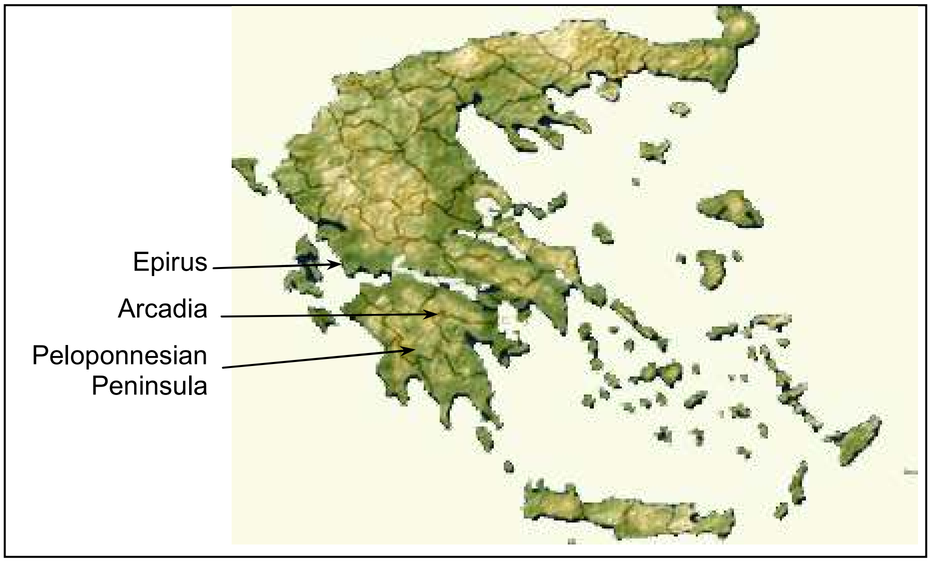
Although Homer makes no mention of him, Charon is long rooted in Greek lore, originally probably not the ferryman, but possibly as an ancient and respected death-god. A hint comes from Strabo's Geographia (Chapter 3) where the Roman writes of a cave in Asia Minor that was once Charon's sanctuary, a place where priests sought his aid by dream-incubation. If Charon indeed had formerly been a death-god, he would also have possessed an intrinsic power of restoring life. With such power yet within him, yet denied its use by the Olympians, no wonder he succumbed to despair. He is going nowhere but back and forth, constrained, as are we, by the rulers of the day.

In his tragedy Hercules Furens, Seneca (also Chapter 3) describes Charon when the boatman tells Hercules to halt.

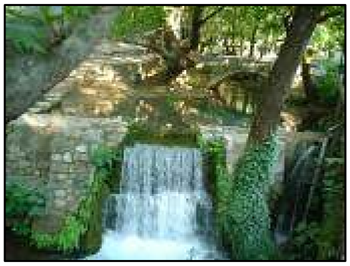
> *A rock funereal o'erhangs the slothful shoals, where the waves are sluggish and the dull mere is numbed.*
> *This stream an old man tends, clad in foul garb and to the sight abhorrent, and ferries over the quaking shades.*
> *His beard hangs down unkempt.*
> *A knot ties his robe's misshapen folds.*
> *Haggard his sunken cheeks,*
> *Himself his own boatman, with a long pole he directs his craft.*
> *Again and again in the chapters before us, we will meet this same boatman, always plying the waters below.*

Geographical Correspondences

The map locates Epirus, Arcadia and the Peloponnesian Peninsula where limestone formations of Peloponnesus exhibit numerous watery grottos, giving rise to classical documentation of rivers swallowed into un-plumbable caverns and breaking forth elsewhere.



In the table below are several purported correspondences between waters of the Greek underworld and today's geography.

	Underworld	Modern Geography
Lethe	Oblivion	Springs near Krya (northwest of Athens), location of the Oracle of Trofonios 

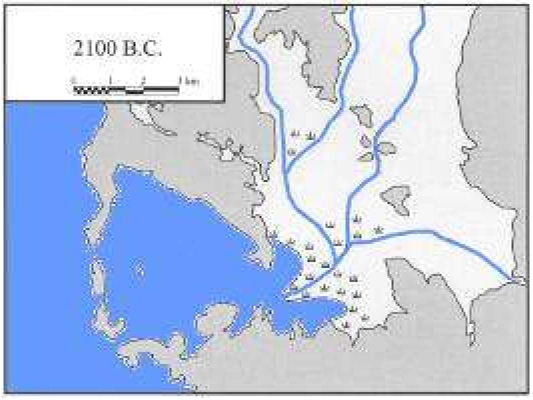
Acheron	Tar with iron plates floating upon it	Thesprotia, southern Epirus
Styx	Circling Tartarus nine times	Mavroneri ("black water") in Arcadia, famous for its 300-m waterfall, the highest in Greece. Visiting in 1895, Sir James Frazer remarked of black waters running down cliffs of dark rock like walls of "ebon hue."
Pyriphlegethon	River of fire	One of many Mediterranean lava flows (Chapter 41)

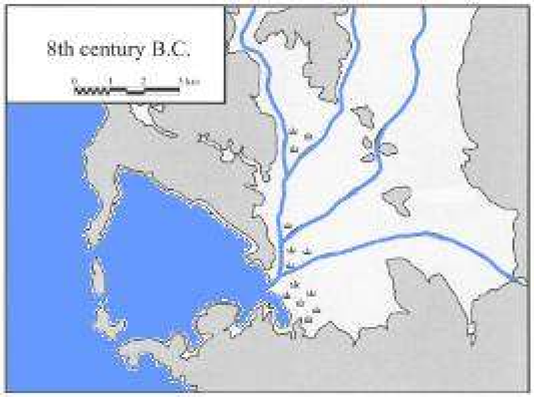
Recalling the CLASP mnemonic, we note that of the several subterranean rivers of Greek myth, only the Cocytus hasn't -- at least nominally -- made its way to the surface.

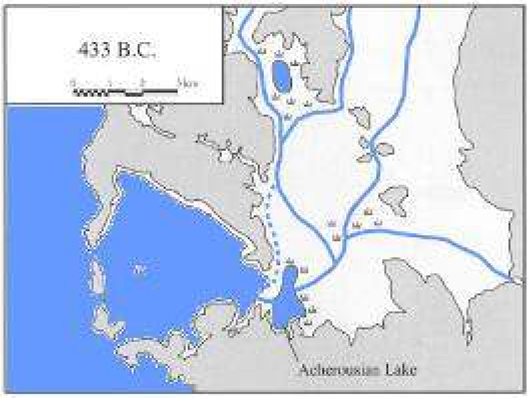
The lower Acheron valley illustrates the metamorphosis of the Peloponnesian landscape. In ancient times the river formed Lake Acherusia, a locale legendarily associated with Charon. The rivers Cocytus and Vouvos (then called Pyriphlegethon) also emptied into the lake, and then all together emptied into the vast Glukys Himen ("Sweet Harbor") noted by Strabo (Chapter 3) and mentioned by Thucydides during the stop of the fleet of the Corinthians the day before the naval battle of Syvota (433 BC).

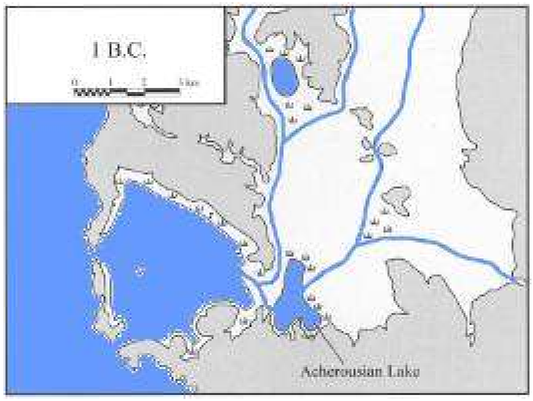
The following four-millennia chronology of the valley is adapted from "The Lower Acheron River Valley, Ancient Accounts and the Changing Landscape," Hesperia Supplements 32, 2003, by Mark Besonen, George Rapp and Zhichun Jing.

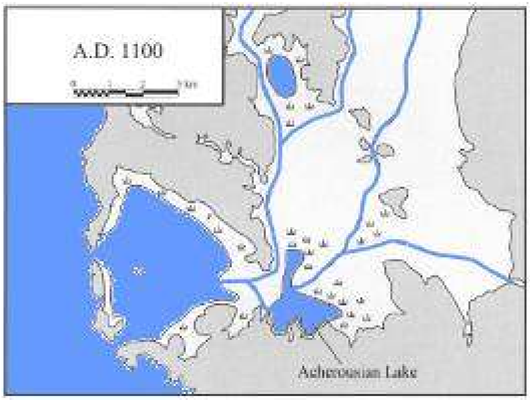
The Ionian Sea is to the left. Today's River Acheron is the channel sweeping from the upper right. Drainage works have reduced Strabo's great Sweet Harbor to the snug moorage of Argo Janni at the Acheron mouth.

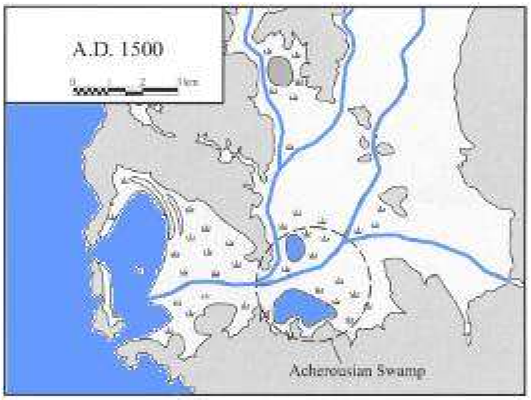

2100 B.C.
0 1 2 3 km

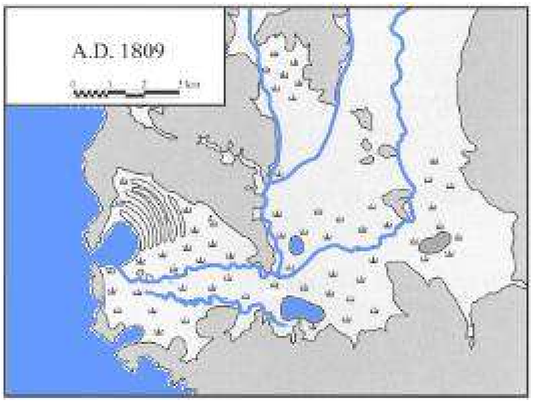

8th century B.C.
0 1 2 3 km

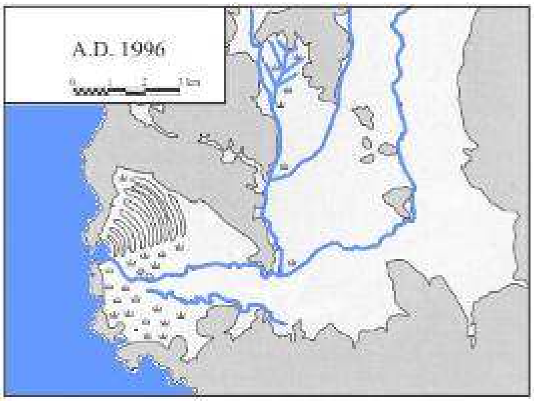

433 B.C.
0 1 2 3 km
Acherousian Lake


1 B.C.
0 1 2 3 km
Acherousian Lake


A.D. 1100
0 1 2 3 km
Acherousian Lake


A.D. 1500
0 1 2 3 km
Acherousian Swamp


A.D. 1809
0 1 2 3 km


A.D. 1996
0 1 2 3 km

As the lore of Charon preceded Lake Acherusia's formation, the ancient ferryman didn't ply the lacustrine surface, but then again, the river flowed long before.

What keeps classicists occupied, of course, is connecting the dots. Let us summarize a bit of how this works. From James Henry Skene, "Remarkable Localities on the Coast of Epirus," Journal of the Royal Geographical Society of London 18, 1848,

> *I had occasion recently to sail into the port of Agio Janni in a small yacht, during a dark night, and blowing hard with violent squalls. In beating into the harbor I was astonished to perceive the sea become suddenly as calm as a mirror, although the wind was increasing, but the calmness lasted only for a moment, and had the appearance as if a few barrels of oil had been emptied over the waves in a particular spot. It was too late that night to make any investigation into the causes of this, but on the next morning I returned with a light breeze in search of the spot, and found a circular space of perfectly smooth water, the diameter of which might be about 40 feet; and it appeared to be raised above the surface of the surrounding sea. The water rose from beneath with such violence as to form a series of small circular waves beyond the ring diverging from the center, which was turbid, and bubbled up like a spring. We steered across it, and found that the cutter's head swerved about as in a whirlpool, which convinced me that it was occasioned by a powerful submarine source, or perhaps the outlet of one of the Katabothra, or subterranean channels, which flow out of the lake of Jannina.*
>
> *Now Pausanias mentions the fact of these phenomena existing on the coast of Argolis, and in Thesprotia, near the place called Chimerium.*

Skyne now cites the day's authority on all things Greek, Col. William M. Leake. From Leake's Travels in the Morea II (1830),

> *This is a copious source of fresh water rising in the sea, at a quarter of a mile from a narrow beach under the cliffs. The body of fresh water appears to be not less than fifty feet in diameter. The weather being very calm this morning, I perceive that it rises with such force as to form a convex surface, and it disturbs the sea for several hundred feet around. In short, it is evidently the exit of a subterraneous river of some magnitude, and thus corresponds with the Deine of Pausanias* [a second century traveler whom we'll encounter in Chapter 3]*, who remarks in the Arcadics, that the waters of the plain in the Mantinice... flow towards a chasm, and that, after a subterraneous course, they re-appear at the Deine, towards the place in the Argolis called Genethlium; here sweet water rises out of the sea in the same manner as near Cheimerium in Thesprotis.*

Skene thus concludes,

> *These two phenomena, therefore, strongly resemble each other, and they may well be mentioned by the ancient geographer as being similar. The modern geographer* [once more referring to Leake]*, in his travels in Northern Greece, says himself that if the remark of Pausanias were verified, he states that fresh water, similar to that of the Deine on the coast of Argolis, rose in the sea near Chimerium..., there would remain no doubt on the subject.*

Scholar cites earlier scholar who in turn cites ancient scholar. Parallels between Greek myth, ancient travelers and personal observation put Skene's doubt to rest and voila! -- the ancient Acheron -- the above-ground part, that is -- is reconciled with modernity.

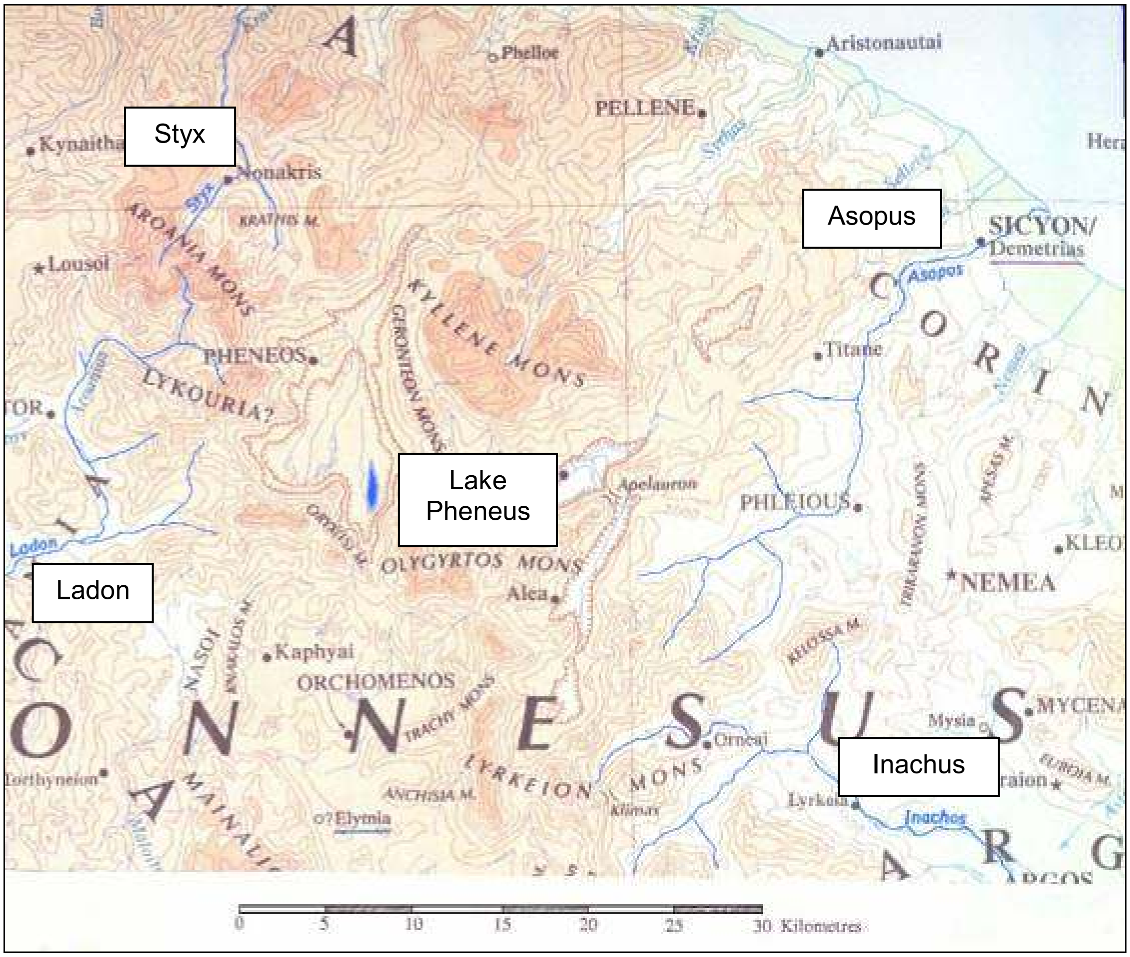
What interests us more than which ancient swamp is what current river, however, is the nature of the supposed underground watercourse popping up in the diminished bay. Were this the case, there would two Rivers Acheron, one subtending the other.

At the risk of dampening historic sleuthing, we must note that actual geo-science -- the kind that employs thermometers and such -- knows of no such sub-oceanic upwelling. Yachters need not fear a "convex surface" off the sunbather-spread white sands.

Pausanias appears to have swayed the colonel with an honored yarn and the latter likewise planted a seed in Skene's expectations.

Seek, and ye shall find, as it says in the Bible. As the chapters ahead will attest, underground rivers seem to thus be identified. Leake would have planted (or re-planted, as it were) many such literary predispositions, as his Travels in Northern Greece (1835) contains no less than 60 references to the "subterraneous."

As for correspondence to legendary sites, the map below shows modern Lake Pheneus as the grain-shaped water body near the center, said to be the excavation of Hercules.


Styx
Asopus
Lake Pheneus
Ladon
Inachus
Phelloe
Aristonautai
PELLENE
Kynaitha
Nonakris
KRATHIS M.
AROANIA MONS
Lousoi
SICYON/ Demetrias
KYLLENE MONS
GERONTION MONS
PHENEOS
LYKOURIA?
Titane
CORINTH
Apelauron
PHLEIOUS
TRIKARANON MONS
APESAS M.
KLEO
NEMEA
OLYGYRTOS MONS
Alea
Kaphyai
ORCHOMENOS
TRACHY MONS
KELOSSA M.
Mysia
MYCENAE
Orneai
LYRKEION MONS
Lyrkeia
Inachos
Thorthyneion
MAINALIA
ANCHISIA M.
Elymia
PELOPONNESUS
ARGOS
0 5 10 15 20 25 30 Kilometres

The Styx (one of several, as we'll see in Chapter 55, A Superfluity of Surficial Stygian Streams), Asopus, Inachus and Ladon (tributary to the westerly Alpheus) encircle Lake Pheneus. Only from a topographic map can we have confidence in a river's direction, or alternatively, given a particular reach of water, can we be sure of to which basin it belongs. Only in recent mapping was it determined that the Ladon drains the region through the underlying limestone.

Nearby this Styx lies the Monastery Mega Spiel, founded in 362 upon a grotto, and Limn Kastrion Cave, 3 kilometers of underground lakes linked by waterfalls.

The photo shows one of many nearby caverns. If there was an entrance to the underworld, this Arcadian region looks to qualify.

Basins such as these keep modern hydro-cartographers employed and -- as we will see in Chapters 19-25 -- likewise the writers of pulp fiction.

To confuse an early geographer reliant on oral accounts, there are no less than three Asopus rivers:

The Asopus above,
The Asopus of Boeotia, northwest of Athens, emptying into the Euboean Gulf, and
The Asopus on the Anatolian uplands of Sakarya, modern Turkey.

Sophocles said that the Inachos of Akarnania in Epirus joined the Inachos of the Argolid.

Strabo (Chapter 3, Roman Geographers) saw the problem of colonists transferring familiar names to make the new land seem more like the old.

> *Hecataeus ... says that the Inachus of the Amphilochi, which flows from Mount Lacmus, from whence also the Aeas descends, was distinct from the river of like name in Argolis, and was so named after Amphilochus, from whom likewise the city of Argos was denominated Amphilochian.*

To geographers working from orally-derived accounts, however, like-names may have been thought to be re-emerged reaches of a single watercourse.

Here's the summary of a tale older than geography itself, however.

Asopus, god of the Peloponnean River and son of Oceanus, was married to Metope, daughter of river-god Ladon. Asopus' siblings included Acheron, Alpheus, Inachus, Styx and Maender -- the latter etymologically recognizable today as a riverine pathway. Asopus and Metope had twenty daughters, several of which were carried off by other gods.

The daughters of river deity -- and not insignificantly, nieces to gods of underground waters -- are kidnapped to distant lands. Any reasonable Greek would of course expect to come upon them in his travels.

We thus have

Underground rivers inexorably woven into ancient, but flexible, myth,
Contorted fluvial geomorphology and altered names, and
Rivers observed to disappear into or rise from the ground.

What particular watercourse was denoted by a certain name at a given time may never be clear. What is clear, however, is that myth, geography and mysterious waters are already intermeshed.

We've begun our journey in mythical Greece, the source which, among other things, named our planets, gave us Cupid, Chaos, Eros, Hades, the word "ocean," the Olympics. Underground rivers are very much a part of that legacy.

As the Greeks were only one of many cultures with mythology pertaining to the underground, however, we could have begun with subterranean tales from the Scandinavians, Tetons, Celts and Welsh, the Chinese and Japanese, the Arabs and Central Asians, the Cherokee, Hopi, Lakota, Mandan, Navajo, Pajaritan and Shawnee Native Americans, the Amazonians, Aztecs and Incas, the Australian aborigines, the Bengals and Burmese, the Micronesians, Melanesians and Malaysians, the Persians, the Buddhists and the Hindus.

Although we direct our interests toward Western culture, we must note that both myth and philosophy filtered across the Euro-Asian landmass. Sanskrit scripture written between the 16th and seventh century BC instructs,

> *These eastern rivers, dear son, flow along to the east and the western ones to the west. They arise from the ocean and merge into the ocean and become that ocean itself.* -- Chandogya Upanishad, 6.10.1-2

“Arise from the ocean” sounds very much like evaporation, and if so, the Hindus had a 3,000-year lead in the field of hydrology.

In Sumerian tradition, Enki was Snake Lord of the Abzu (Greek "abyssos," English "abyss"). His ziggurat temple, surrounded by Ephratean marshlands, was the E-engura, the "house of the subterranean streams."

But as we must sail onward, we can only tip our hats to the Snake Lord before we move to philosophy.

CHAPTER 2
GREEK PHILOSOPHERS

Let's begin this chapter -- the title of which simply replaces "Mythology" with "Philosophers," but it's still Greek -- with a summary of our journey to this point. We embarked into a shadowy underworld of murky and ill-defined rivers destined for perhaps nowhere. And as we know from Greek myth, the gods who rule such things can be rather capricious. An inauspicious start.

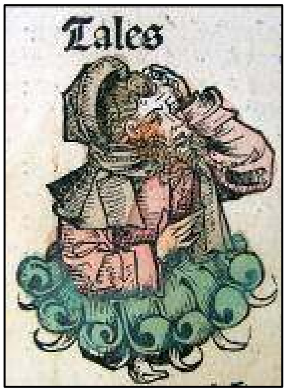
But there are lanterns ahead!

The Greeks' pivotal contribution to Western civilization was not the family of remembered deities. Nor was it the yet-retold epic tales of human fete. The greatest contribution was that of a natural philosophy, by which we mean the scholarly discipline that in ancient and medieval times pursued an orderly investigation of our physical world. The field today is called "science," as contemporary philosophers have come to be seen -- perhaps incorrectly, but we're talking about public perception -- as contemplators of the intangible.

The intellectual challenge in Hellenist times was that of recognizing the patterns. As contrasted in the Introduction, whether such determination is "scientific" or "superstitious" can only be judged by one who knows reality. Most of us today have an inviolate, physically-based bias in the matter, of course, but we'll not impose our predilections on those 2,000 years before us.

We will draw most of this chapter's illustrations from Hartmann Schedel's Nuremberg Chronicle (1493), the German reference of its time regarding matters classical. While we rather doubt that the ancient Greeks dressed as Teutonic burgomasters, the drawings serve a larger point, a theme we will again and again encounter in our journey. As cultural creatures, we're forever regarbing past beliefs.

Born in Miletus (now part of Turkey), our first three Hellenist philosophers were Milesians, the etymological source of "millers." It's doubtful that these three ground grain, however, as they weren't slaves.

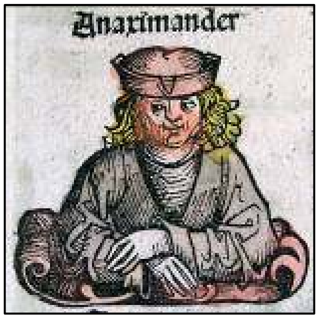


Thales of Miletus (624-546 BC) is best remembered for his prognosis of a solar eclipse. Likely having traveled to Egypt where eclipses were long chronicled and observing that a year contains 365, not 360, days probably accounted for his accuracy.

Thales was a monist, one believing that all substance is derived from a single primordial matter. To Thales, the world was water, the only substance having solid, liquid and gaseous form. Moreover, nourishment for both plants and animals is moist. Water is thus an image of a cosmic unifying power. (Note the qualification, "image of," however. We'll see how Plato institutionalized the concept of duality later in this chapter.)

Sidestepping religious tradition, Thales concentrated on natural processes. "All things being full of gods," supported both religious lore and a physical River Oceanus flowing unceasingly around the earth. Under the effect of winds, waters of the seas were thrust towards the interior, elevating the pressure within and causing underground rivers to erupt through earthquake in the earth's skin.

Hydrologists think of Thales as the water-philosopher, but in larger picture, it was this philosopher who argued that for every observable effect, there is a physical cause. The term "physical" marks the onset of what we know today as "science."



Thales' disciple Anaximander of Miletus (611-547 BC) went a further step, seeing the primordial substance as “apeiron,” a substance less tangible. Realizing that the earth was curved, Anaximander concluded the earth’s shape to be that of a cylinder, but one placed within in a celestial sphere.

To the right, Anaximander holding a sundial

Anaximenes

Anaximenes of Miletus (585-525 BC), said to be the first to distinguish between stars and planets, argued that world is composed of neither water nor apeiron, but of air itself. Compressed, it becomes water and earth.

Anaximenes reverted to the disk cosmology, stating that the sun never goes under the earth, but circles it laterally, sometimes obscured by higher parts. The sea is,

> *The source of the water and the source of the wind. For neither could the force of the wind blowing outwards from within come into being without the great main sea, nor the streams or rivers, nor the showery water of the sky, but the mighty main is the begetter of clouds and winds and rivers.*

Anaximenes explained landforms as the product of surficial collapse, a rational fitting well with the Arcadian multitude of caves. Water percolates the earth, as "in certain caves water drips down."

Not satisfied with explanations reliant on a supernatural where the eye can not peer, the Three Milesians proposed physical, autonomous theory. If Bertrand Russell’s reflection, “It is not what a man of science believes that distinguishes him, but how and why he believes it,” in A History of Western Philosophy (1945) yet stands, the field of natural science was born in Milet.

Underground rivers (or anything physical, for that matter) are not manifestations of arbitrary powers, but are orderly, consistent and objective outcomes of natural rules.

Xenophanes of Colophon (570-470 BC) merits mention in our chronology.

> *The sea is the source of the waters and the source of the winds. Without the great sea, not from the clouds could come the flowing rivers.*

Xenophanes was onto something remarkable, that the waters of the earth are interdependent. He, of course, wasn't the first to recognize the link, but he was among the first to record the tie as a natural dependency, not as divine whim.

Xenophon phus

As we shall note in Chapter 4, The Cross, however, subsequent theological doctrine and uncritical observation will for another two millennia cite similar declarations to justify the uphill flow of underground rivers.

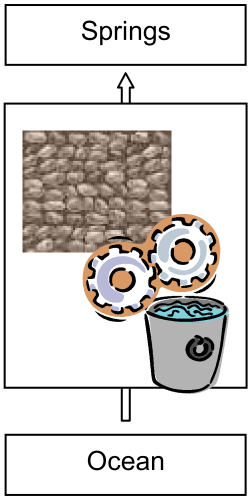
Heraclitus of Ephesus (540-475 BC) added the temporal dimension to questions of hydrology. “No man can twice step into the same river” isn’t just about rivers, of course, but about development and decay, a causal chain for water’s perpetual mobility.

Heraclitus

Heraclitus noted the following.

> The sun is a bowl, the concave side turned towards us, in which the bright exhalations from the sea collect and burn.
>
> The vapor, after kindling and going out again, reappears as dark clouds and fiery water spouts resembling smoke and comes down as water.
>
> As the sea is increased by rain, water passes into the earth.
>
> As the sea is diminished by evaporation, the earth is proportionally liquefied.
>
> At any moment, half of the sea is taking the downward path, having just been a fiery storm cloud, while half of it is going up, having just been earth.

We're not told the means, but we can draw a schematic.



Anaxagoras

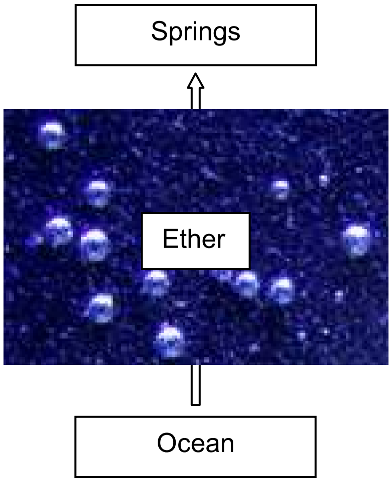
Anaxagoras of Clazomenae (500-428 BC) lived in Athens until being accused of heresy for asserting that the sun is not a god. Anaxagoras solved the enigma of the Nile's floods, which contrary to the regime of other Mediterranean rivers, occur in summer. To Anaxagoras, the flooding was due to Ethiopian snowmelt.

Anaxagoras envisioned percolated rainfall gathered in subterranean caverns, hydrology's first reservoir theory.

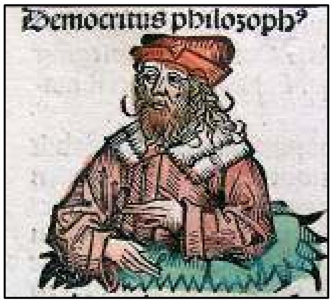
> *Rivers depend for their existence on the rains and on the water within the earth, as the earth is hollow and has water in its cavities.*

The substratum rests on ether, the lightest of all elements, which in streaming upward, entrains cavern-trapped rain water and caries it to springheads. Streams that cease flowing in summer are fed from reservoirs too small to store enough water. Differing from Heraclitus, no new water is generated within the earth.

Here's a schematic version of Anaxagoras' model.



If the porous upper stratum is plugged by downpours, the ether may exit forcibly as an earthquake.



Democritus (460-370 BC) held that the world was round and was composed of tiny atoms. His cosmology can be summarized by words from the poet Percy Shelley (1792-1822).

Worlds on worlds are rolling ever
  From creation to decay,
Like the bubbles on a river
  Sparkling, bursting, borne away.

We will later turn to Democritus to explain how "salt" atoms might drive underground fresh-water rivers to mountain springs.

Hippon of Samos (c. 450 BC) wrote that all rivers, springs and wells have their source in the ocean because the sea is the deepest, a unifying physical explanation for hydrologic linkage. While invalid in light of modern hydrostatics, we're more-and-more seeing a logic that's turning toward physical law.

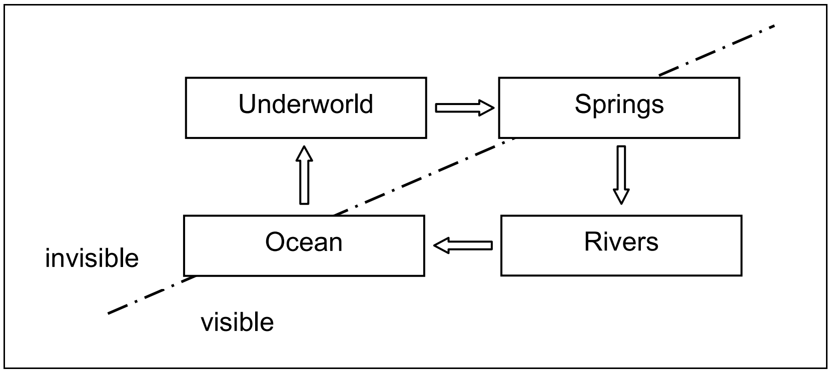
Like his mentor Socrates (470-399 BC), Plato (428-348 BC) dismissed truth by observation, seeing “form” as the essence that relates to with what it participates. Plato’s universe is the product of divine intelligence, the “Demiurge,” the personification of reflection and reason. Physical experiment is but a base art.

Socrates phus

As did his teacher, Plato found little problem in reverting to folklore for questions of mere substance. Plato’s Timaesus tells of Atlantis, larger than Asia and Libya together, located on the far side of the Pillars of Hercules (modern Gibraltar). He visited Sicily in 387 BC to view Mt. Etna which eleven years before had produced one of its greatest eruptions (Chapter 3), but Plato's thoughts did not stoop to geology. If anything, the devastation cemented Plato’s reliance on the supernatural.

Timaesus also furthered the paradigm of microcosm and macrocosm, a world view to persist for another 2000 years. To understand the cosmos, we need only know the anatomical, physiological and psychological structure of man. We'll see the implications for underground rivers in Chapter 8, Transmutational and Bilological Engines.

The schematic suggests how Socrates and Plato would have viewed the flow of springs.



The Platonic Hydrologic Cycle

Re-label “Springs” as “Craters” and note that Etnean lava flowed as rivers to the sea and the upward arrow becomes the River Pyriphlegethon. In the case of water, Plato's visible portion is correct. It is in the unseen portion where arrows are misdirected that has come to be known as a “reversed” hydrologic cycle.

In Phaedo, note Plato's use of "wider channels," what seem to be river-like passageways.

> *But all these are in many places perforated one into another under the earth, some with narrower and some with wider channels, and have passages through, by which a great quantity of water flows from one into another, as into basins, and there are immense bulks of ever-flowing rivers under the earth, both of hot and cold.*

In Critias, written some years later, Plato refers to the Athens region in former times.

> [Rainwater was] *not lost to it, as now, by flowing from the bare land into the sea; but ... , storing it up in the retentive loamy soil, and by drawing off into the hollows from the heights the water*

> *that was there absorbed, it provided all the various districts with abundant supplies of spring-waters and streams.*

Perhaps recounting ancient Athens through the voice of the historical figure Criticas freed Plato's mind to ponder more of the the mundane.

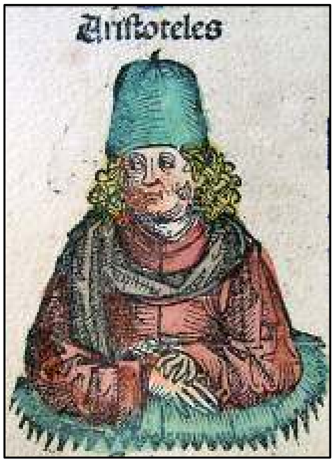
> *He* [Plato] *says that they all flow into each other beneath the earth through channels pierced through it, and that their original source is a body of water in the center of the earth called Tartarus, from which all waters running of standing are drawn. This primary and original mass causes the flow of various rivers by surging perpetually to and fro; for it has no fixed position but is always oscillating about the center, and its motion up and down fills the rivers. Many of them form lakes, one example of which is the sea by which we live, but all of them pass round again in a circle to the original source from which they flowed; many return to it again at the same place, others at a point opposite to that of their outflow, for instance if they flowed out from below, they return from above.*

Plato identifies Tartarus as the underworld's lowest abyss because it pierces through the whole earth. Repeating Anaxagoras, all waters begin in Tartarus and endlessly journey to return to their Tartarean source. Water does this because a liquid has no bottom or foundation; hence, it oscillates up and down as do air and winds. Points of egress and ingress may be close together or far apart.

That much said, however, we must note that Plato identified little with Homer's world view. As reality is something else, the latter's version about Tartarus was good enough. Had not Aristotle -- concerned with worldly things more than was than Plato -- not quoted his teacher as a basis for further discussion, we'd not have Plato's reference to the myth. Plato, we must suppose, wasn't arguing for the folklore's veracity as much as he was summarizing popular belief.

Plato's successors as head of his Academy, Speusippus and Xenocrates, deemed in turn that mathematics was the highest level of existence, even primary to soul. We can only speculate if such metaphysics might have segued into quantifiable science had not the Romans sacked the Academy in 86 BC.

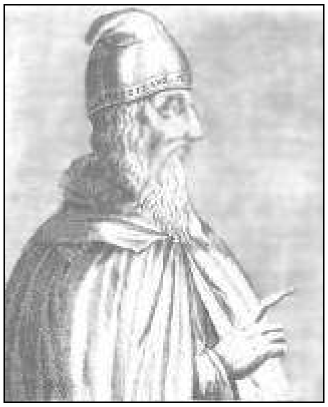
At age 17, Aristotle (384-322 BC) enrolled in the Academy where the master soon called him the "mind of the school." Aristotle remained at the Academy until Plato's death, after which Aristotle became a teacher himself, spending two years studying marine biology on Lesbos where he recognized dolphins as mammals.



ΜΕΓΑΣ ΑΛΕΞΑΝΔΡΟΣ
ΔΡ. 2 ΕΛΛΑΣ ΔΡ. 2

Italian Banknote, “The School of Athens” by Raphael (1483-1520)

Plato and Aristotle stand at the center. Plato (on the left) is modeled after da Vinci, another underground-river scholar with whom we will come to be relentlessly acquainted in Chapter 7, The Concept of Circulation.



An equally-unlikely representation of Aristotle, André Thevet's “Les Vrais Pourtraits et Vies Hommes Illustres” (1584). The philosopher in Reminiscence garb may not be that far-fetched, however, as he'd only grown more popular.

In contrast to Plato's emphasis on the abstract, Aristotle's reality was derived through the senses. The world is comprised of individuals grouped into fixed kind -- “speciation” to a modern biologist. Each individual has an inherent pattern of development toward a group-defined self-realization. Growth, purpose, and direction are thus built into nature. Humankind’s purpose is to reason. Zoology rested on Aristotle's foundation until Charles Darwin disputed the fixity of species in 1859.

The earth and the heavens are subject to unlike natural laws -- earthly things are changeable and corrupt, while the heavens are permanent. The regenerative process keeps the decaying earth in equilibrium within an eternal universe. Nature’s purpose is to maintain balance and Aristotle’s interest was that of finding the predefined function teleology each component.

Matter is of four sensible qualities: cold, hot, wet and dry. We will see the geophysical implications of transmutation in Chapter 8; it opens up a multitude of explanatory possibilities. Aristotle’s factor of tens (“decuplo”) established that proportionality 1:10:100:1000 for earth, water, air and fire, respectively.

Aristotle criticized Plato's subterraneous reservoir theory, noting that Tartarus would have to be impossibly large.

> *But if anyone will picture to himself a reservoir adequate to the water that is continuously flowing day by day, and consider the amount of water, it is obvious that a receptacle that is to contain all the water that flows in the year would be larger than the earth, or, at any rate, not much smaller.*

Aristotle likewise rejected that streamflow was generated in upland lakes.

> *The fact that rivers have their sources at the foot of the mountains proves that the place accumulates water little by little by a gradual collection of drops, and that the sources of rivers are formed this way. It is of course not at all impossible that there do exist such places containing large amounts of water, like lakes; but they cannot be so large as to act in the way this theory maintains, any more than one could reasonably suppose that their visible sources supply all the water for the rivers, most of which flow from springs. It is thus equally unreasonable to believe either that lakes or that the visible sources are the sole water supply.*

Aristotle recognized that vapor from marine evaporation causes rainfall.

> *Now the sun, moving as it does, sets up processes of change and becoming and decay, and by its agency the finest and sweetest water is every day carried up and is dissolved into vapor and rises to the upper region, where it is condensed again by the cold and so returns to the earth.*

He likewise recognized the principle of a hydrologic cycle.

> *For according as the sun moves from side to side, the moisture in this process rises and falls. We must think of it as a river flowing up and down in a circle and made up partly of air and partly of water.*

Aristotle looked upon cool mountains as the site of direct condensation. The water so condensed was then held by then like water in saturated sponges to be gradually released in springs.

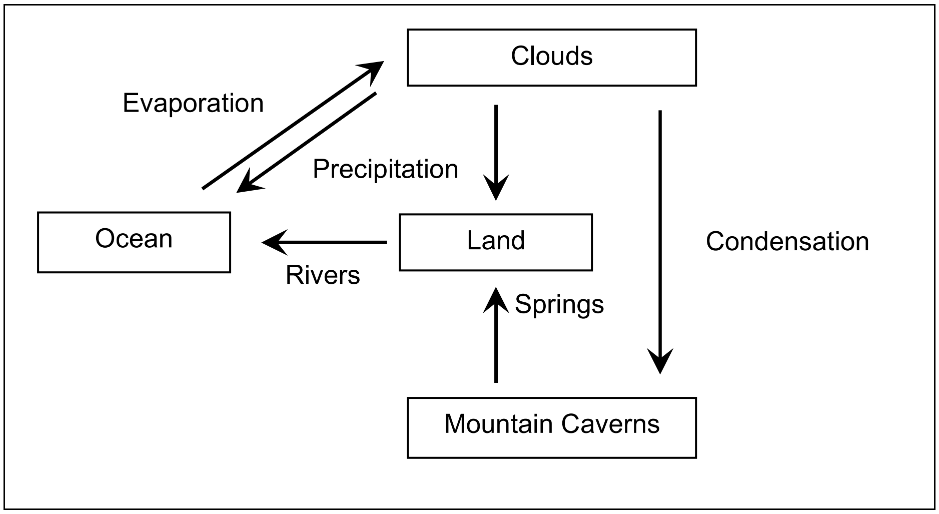
> *The process is rather like that in which small drops form in the region above the earth, and these join again others, until rain water falls in some quantity; similarly inside the earth, as it were, at a single point, quantities of water collect together and gush out of the earth and form the sources of rivers. A practical proof of this is that where men make irrigation works they collect the water in pipes and channels, as though the higher parts of the earth were sweating it out.*
>
> *Similarly, the majority of springs are in the neighborhood of mountains and high places, and there are few sources of water in the plains except rivers. For mountains and high places act like a thick sponge overhanging the earth and make the water drip through and run together in small quantities in many places. For they receive the great volume of rain water that falls... and they cool the vapor as it rises and condense it again to water.*

The question becomes, from where does such water rise?

According to Aristotle, it rises from both below and above the earth. Keeping in mind that Aristotle did not distinguish between air and water vapor,

> *It is unreasonable for anyone to refuse to admit that air becomes water in the earth for the same reason that it does above it.*
>
> *The air surrounding the earth is turned into water by the cold of the heavens and falls and rain... The air which penetrates and passes the crust of the earth also becomes transformed into water owing to the cold which it encounters there. The water coming from the earth unites with rainwater to produce rivers. The rainfall alone is quite insufficient to supply the rivers of the world with water.*

Let us reduce Aristotle's thoughts to a schematic, a much enhanced of the earlier one done for Heraclitus.



Aristotle's Hydrologic Cycle

Had Greek thought continued to advance, we can only speculate that the scientific realizations of the 17th century might have occurred much earlier. But were that the case, we'd be already approaching the end of our journey, and in counting the pages, we're not even close.

In the first chapter, we floated through the Greek underworld with little hope or comprehension. The philosophers of this chapter haven't made our journey a pleasant excursion, but they've admirably argued for an underlying order to the flow.

We keep in mind the nagging fact that in our journey so far, none of the pundits have themselves seen the waters of which we speak.

Perhaps what we need are some able note-takers, scholars who'll help us find a pattern in the fluvial underground. With that in mind, let's go to Rome.

CHAPTER 3

ROMAN ENCYCLOPEDISTS

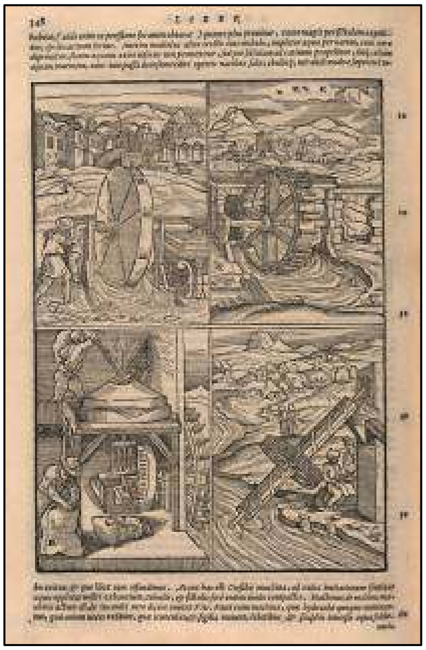
We title this chapter "Encyclopedists" because Rome's contribution to knowledge of underground rivers derives in most part from a mindset. A Roman intellectual's task wasn't to ponder, but rather to harvest and standardize. The Greeks birthed democracy; the Romans codified the law. We benefit from both.

Marcus Terentius Varro (116-27 BC) typifies the result: a systematically partition of knowledge into the seven liberal arts.

Grammar,
Rhetoric,
Logic,
Arithmetic (number in itself),
Geometry (number in space),
Music (number in time), and
Astronomy (number in space and time)

As in our own journey, we're not ourselves conceiving ideas about underground rivers; we're grouping the ideas we find into a sequence of chapters.

The Romans' legacy was Latin as the Western world's intellectual lingua franca for a millennium and a half.



Engineer Marcus Vitruvius' (80-20 BC) greatest contribution to the Cesar's empire was not constructed works, but rather his ten-volume De Architectura, the eighth volume being De Aquis et Aquaeductu. A technology-laden page from the 1567 edition is shown to the right, testament to the lasting power of the book.

Our interests, however, pertain more to Vitruvius' allusions to rivers beneath the earth's surface. As in a hot bath, according to De Aquis, waters on the earth are heated by the sun to form vapors and clouds which when they impact the mountains,

> *Swell, and become heavy, break and disperse themselves on the earth. The vapors, clouds and exhalations which rise from the earth seem to depend on its retention of inner heat, great winds, cold moisture and large proportion of water. Then when from the coolness of the night, assisted by darkness, winds arise and clouds are formed in damp places, the sun, at its rising, striking on the earth with heat power, and thereby heating the air, raises its vapors and dew at the same time.*

Vitruvius describes the amount and taste of water which might be found in different soils and notes how mountain snowfall issues forth as springs.

> *The trees which grow in great numbers in the mountains contribute to the accumulation of snow during long periods, after which it begins to slowly percolate beneath the soil, and this same water, once infiltrated, arrives at the foot of the mountains, the location of springs.*

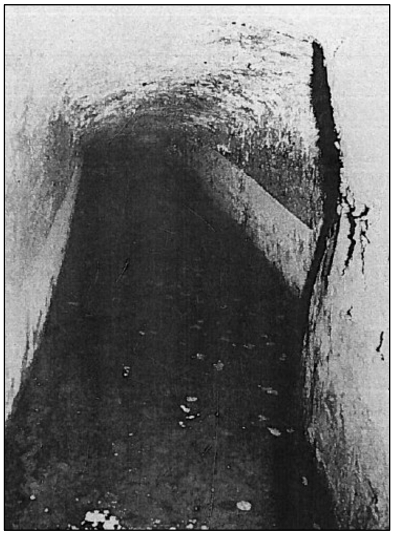
What we quote is reasonably correct, but doesn't move to reasons. Had Vitruvius cited a principal such as gravity, for example, subsequent natural philosophers might have had more doubt about a route from the sea to the feet of mountains.

Strabo (63 BC-24 AD), master of Greek literature, traveler and philosopher, is best known for his 17-volume Geographia, a geographical compilation from works that largely have not survived.

Strabo attributed the fire of Mt. Etna and of the volcanic island Thermessa to combustion because when the winds die, so do the flames. The wind is in turn fueled by evaporation from the sea. Incorrect, we might judge, but at least there's a hint of the type of causality espoused by the natural philosophers from whom he was drawing.

Strabo reported “the Cave of the Sibyl” within the Phlegraean Fields in the sulfurous caldera of Mt. Vesuvius near modern Naples, exactly the type of clue that fuels archeologists. Discovery in the 1960s of a hewn tunnel descending 40 meters in hot rock to an artificial channel going nowhere may have resolved the question. The layout conforms to Virgil's description in the Aeneid of Aeneas' journey to the underworld. Quoting from the Smithsonian.com October 1, 2012 feature, "The Unsolved Mystery of the Tunnels at Baiae,"

> [The tunnel system may have] *been constructed by priests to mimic a visit to the Greeks’ mythical underworld. In this interpretation, the stream represented the fabled River Styx, which the dead had to cross to enter Hades; a small boat, the explorers speculated, would have been waiting at the landing stage to ferry visitors across. On the far side these initiates would have climbed the stairs to the hidden sanctuary.*
>
> *The tunnels.... might have been constructed to allow priests to persuade their patrons -- or perhaps simply wealthy travelers–that they had traveled through the underworld. The scorching temperatures below ground and the thick drifts of volcanic vapor would certainly have given that impression. And if visitors were tired, befuddled or perhaps simply drugged, it would have been possible to create a powerfully otherworldly experience capable of persuading even the skeptical.*



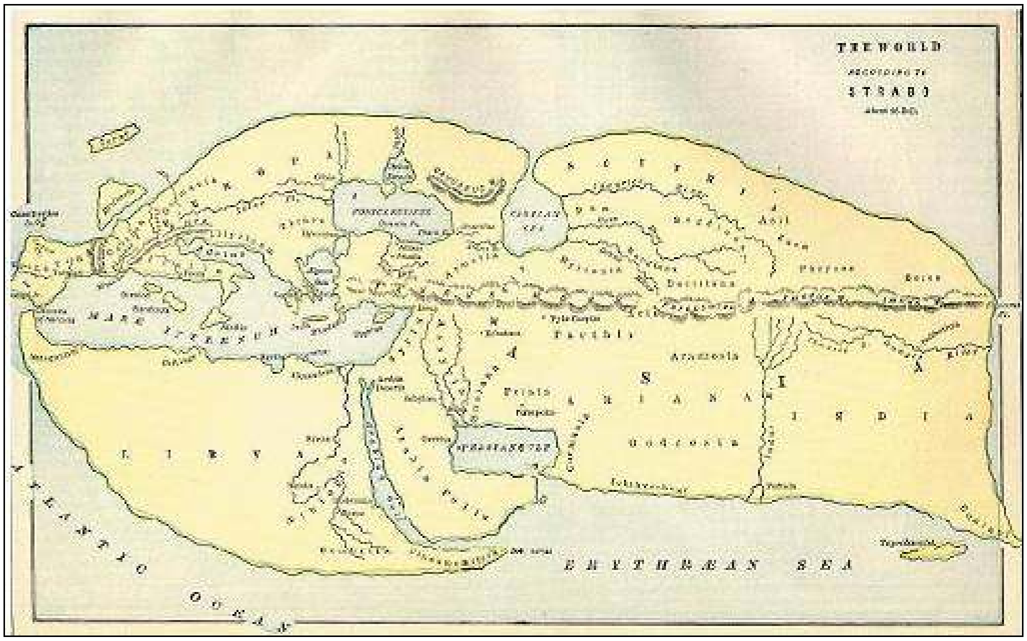
We'll have more to say about Leonardo da Vinci's and Athanasius Kircher's interest in Mount Vesuvius in Chapter 9 (Thermodynamic Engines).

Strabo was the recorder of many “lost river” accounts, among them, the loss of the Timavus east of Trieste in a cavern and its reappearance at the coast -- a river we'll travel in Chapter 72, Underground and Balkanized. Other lost rivers include,

> *Erasmus which now flows underground from the Stymphalian Lake and issues forth into the Argive country, although in earlier times it had no outlet, since the berethra* [pits] *which the Arcadians call "zerethra" were stopped up and did not admit of the waters being carried off.*
>
> *Those who would have the river Inopus to be a branch of the Nile flowing to Delos, exaggerate this kind of marvel to the utmost.*
>
> *There is even a story* [from Pausanias] *that the Nile itself is the Euphrates, which disappears into a marsh, rises again beyond Ethiopia and becomes the Nile.*

A lost river story rejected by Strabo is one in which "the mouth of the river empties into the sea in full view and there is no mouth [whirlpool] on the transit, which swallows it up."

Although Strabo noted what were said to be lost rivers, his encompassing geographical compilation -- his lasting contribution -- showed none.



Strabo's Geographia notes what may have been a geographical root of Charon.

> *One comes to a village* [in Karia, Asia Minor]*, the Karian Thymbria, near which is Aornon, a sacred cave, which is called Charonion, since it emits deadly vapors.*

Strabo mentioned that Lake Copais north of the Peloponnese was drained naturally by an underground channel some 5 kilometers in length which rose again near Larymna.

From Herodotus' Persian Wars (c. 435 BC),

> *When Cleomenes had sent to Delphi to consult the oracle, it was prophesied to him that he should take Argos; upon which he went out at the head of the Spartans, and led them to the river Erasinus. This stream is reported to flow from the Stymphalian lake, the waters of which empty themselves into a pitch-dark chasm, and then (as they say) reappear in Argos, where the Argives call them the Erasinus.*

Drawing upon this, Strabo described a subterranean connection between the River Stymphalus (and, by extension, Lake Stymphalus) and the Argive River Erasinus, placing the river's emergence at a spring between Argos and Lerna. We'll have more to say about the area's hydrology in Chapter 28, Et In Arcadia Ego.

Strabo stated that at one time the sink was blocked by an earthquake, making the lake much larger. Citing the authority Eratosthenes (c.275-194 BC), Strabo noted that the sink occasionally plugged, causing flooding near Pheneus and a flood surge downstream.

During the Battle of Mantinea, 418 BC, the Spartans were said to have flooded the path of their enemies by diverting the River Sarandapotamos to the bed of the smaller River Zanovistas and plugging the latter's sinkholes.

In like manner, when Iphicrates was besieging the Spartan town of Stymphalus some years later, it was said that he attempted to innundate the defenses by blocking the sink with sponges.

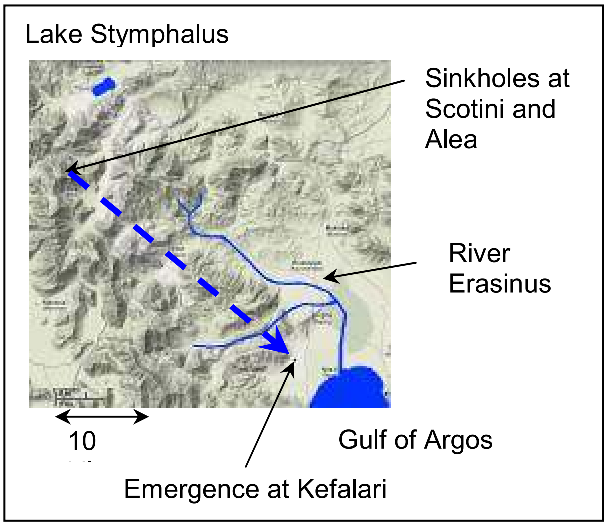
The Stymphalus was said by Diodorus of Sicily, writing between 56 and 36 BC, to descend underground through a sinkhole, flow 32 kilometers through underground passages, and resurface before emptying into the Gulf of Argos.

In Publius Ovidius Naso's (43 BC-17 AD) -- Ovid to us -- Metamorphoses (8 AD), the engulfed Stymphalus "glides in secret eddies underground" before returning as a lordly river in the Argive fields.

POSTE ITALIANE
LIRE 25
BIMILLENARIO DI
OVIDIO
43 AC - 1957

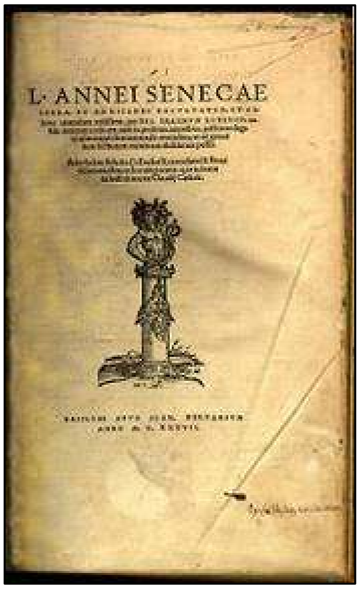
The modern Peloponnesian water tracing to the right closely agrees with the ancient record. The water flows underground until forced to the surface at Kefalari. We'll learn why in Chapter 39, Karstology.

Near the end of this chapter we'll table more of the encyclopedists' reported subterranean rivers. Most of their reporting hasn't borne out as well as has the Stymphalus-Erasinus pipeline, however.


Lake Stymphalus
Sinkholes at Scotini and Alea
River Erasinus
10
Gulf of Argos
Emergence at Kefalari

The works of Strabo and Ovid would fuel centuries of geologic speculation. From this point onward, the world would know of Greece not only in the sense of myth and history, but also as a landscape of disappearing and reappearing waters.

Born in Spain, Annaeus Seneca (4-65 AD) came to Rome as physician to Nero, who ultimately rewarded his attendant by execution. Seneca's Quaestiones Naturales was an ill-sorted compilation of secondhand ideas. To the right is the cover from a 1542 edition, another hint of how lasting would be the Latin libraries. Seneca, like Vitruvius, would be considered expert in water issues for 1500 years.



L· ANNEI SENECAE

A vast world exists below.

> *There exist below everything that you see above. There, too, are vast, immense recesses and vacant space, with mountains overhanging on either hand.*

Seneca attributed groundwater three sources:

1. Moisture continuously expelled within the earth.

   > *The Sea... does not get larger, because it does not assimilate the water that runs into it, but forthwith restores it to the earth. For the sea water returns by a secret path, and is filtered in its passage back. Being dashed about as it passes through the endless, winding channels in the ground, it loses its salinity, and, purged of its bitterness in such a variety of ground as it passes through, it eventually changes into pure, fresh water.*

2. Sluggish air converted into water within the earth by the forces of darkness and cold. Just as a change in atmospheric density produces rain, a change of density beneath the earth turns air into water. Locked in perpetual darkness, frigidity and inertness, the subterranean forces supply the springs above without pause.

   > *We Stoics are satisfied that the earth is interchangeable in its elements. So all this air that she has exhaled in her interior, since it was not taken up by the free atmosphere, condenses and is forthwith converted into moisture.*
   >
   > *There you have the first cause of the origin of underground water.*

   The air above ground can not long remain sluggish and heavy for it is subject, from time to time, to rarefaction by the sun's heat or expansion by the force of the wind.

[A note regarding nomenclature: "Groundwater" and "ground water" are employed with roughly-equal frequency in both technical and popular literature. For internal consistency, we will use the former, except for bibliographic references worded otherwise. "Underground water," on the other hand, is just an adjective and noun, and written accordingly.]

3. Earth converted to water.

   > *All elements arise from all: air comes from water, water from air; fire from air, air from fire. So why should not earth be formed from water, and conversely, water from earth?*

Seneca takes the trouble to refute a standard objection to transmutation. Given the boundless supply of earth, why would water courses and springs ever dry up? His reply is that the course of the water, not its source, is often disturbed by shocks in the earth.

He dismissed the role of rainfall in springflow.

> *Some suppose that all the water that the earth drinks in from rain is sent out again into the rivers... [But] a great deal can obviously be urged in reply to this. First of all, as a diligent digger among my vines, I can affirm from observation that no rain is ever so heavy as to wet the ground to a depth of more than 10 feet... How, then, can rain, which merely damps the surface, store up a supply sufficient for rivers?*

Rain only feeds the regular rivers and creates temporary torrents. As water is “a quarter of nature,” there can be no shortage of it. “Rains cannot produce; they can only enlarge and quicken a river.”

Seneca side-steps the mystery of the Nile's origin by citing 500-year old Greek thought.

> *Oenopides of Chios... says that in winter heat is stored up under the ground; that is why caves are then warm, and the water in wells is less cold. The veins of water are dried up by this internal heat, he thinks. In other countries rivers swell through rain but the Nile, being aided by no rainfall, dwindles during the rainy season of winter.*

As for springs, we should offer sacrifices.

Soil moisture, seen by Seneca in global perspective, moves from north to south.

> *The next account is that of Diogenes of Apollonia... The whole earth is full of perforations, and there are paths of intercommunication from part to part. From time to time the dry parts draw upon the moist. Had not the earth some source of supply, it would ere this have been completely drained of its moisture. Well, then, the sun attracts the waves. The localities most affected are the southern. When the earth is parched, it draws to it more moisture, just as in a lamp the oil flows to the point where it is consumed, so the water inclines toward the place to which the overpowering heat of the burning earth draws it. But where, it may be asked, is it drawn from? Of course, it must be from those northern regions of eternal winter, where there is a superabundance of it.*
>
> *Now, one would like to ask Diogenes, seeing the deep and all streams ire in intercommunication, why the rivers are not everywhere larger in summer? ...Another question-seeing that every land attracts moisture from other regions, and a greater supply in proportion to its heat, why is any part of the world without moisture?*

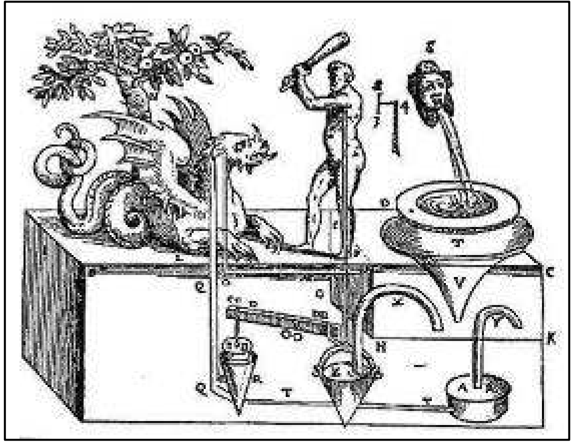
Regarding underground rivers,

> *Rivers are no less existent under the earth merely because they are not seen. You must understand that down there rivers as large as our own glide along, some flowing gently, others resounding in their tumbling over the broken ground. What then? Will you not equally allow that there are some lakes underground and some waters stagnating there without exit?*
>
> *Throughout the entire earth, one of them says, run many different kinds of water. In some places there are perpetual rivers large enough to be navigable, even without the help of rains.*
>
> *Moving air in the lower region inside the earth bursts the atmosphere, thick and complete with clouds, with the same force that clouds in our part of the world are usually broken open.*
>
> *Now permit me to tell you a story. Asclepiodotus is my authority that many men were sent down by Philip* [Philip II of Macedon (382-336 BC), father of Alexander the Great] *into an old mine, long since abandoned, to find out what riches it might have, what its condition was, whether ancient avarice had left anything for future generations. They descended with a large supply of torches, enough to last many days. After a while, when they were exhausted by the long journey, they saw a sight that made them shudder: huge rivers and vast reservoirs of motionless water, equal to ours above ground and yet not pressed down by the earth stretching above, but with a vast free space overhead.*

Heron of Alexandria (10-70) was a Greek engineer and geometer in Roman times. Hero is credited with the first documented steam engine, the "aeolipile." In Dioptra he notes,

> *In order to know how much water the spring supplies it does not suffice to find the area of the cross section of the flow which in this case is 12 square digits. It is necessary also to find the speed of the flow, for the swifter the flow, the more water the spring supplies, and the slower, the less. One should therefore dig a reservoir under the stream and note with the help of a sundial how much water flows into the reservoir in a given time.*

In the field of hydraulics, however, Heron's acknowledgement of velocity fell by the intellectual wayside.



Reconstruction of one of Heron's "automata" by Giovanni Battista Aleoti (1589). When Hercules hits the head of the dragon, the monster shoots water on his face.

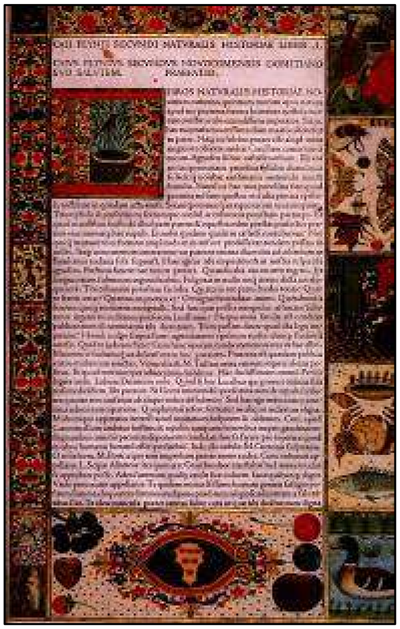
In the chronologic midst of the Encyclopedists, we find Philo (20 BC - 50 AD), a Hellenistic Jew working to harmonize his faith with Greek thought. Paradise may be located, according to Philo,

> *In some distant place far from our inhabited world, and has a river flowing under the earth, which waters many great veins so that these rising send water to other recipient veins, and so become diffused.*

Philo's fellow Hebrews would have little cared about the location of Paradise and his effort added nothing to the Roman cartographic database, but Philo's speculation illustrates the ongoing amalgamation of philosophies. As we will see in Chapter 4, The Cross, the Christians to follow would become adamant proponents of the "river flowing under the earth."

Natural historian Gaius Plinius Secundus (23-79), better known as Pliny the Elder, extracted 20,000 facts from 2,000 volumes to write Naturalis Historia, surely the most ambitious literature review of all time. His “facts” were largely travelers’ tales (e.g., an account of the Monocoli monopodal race), reports of marvels (e.g., a boy commuting to and from school on a dolphin), and ancient belief (e.g., the correlation between celestial bodies and metals, the Sun being gold; Mars, iron; Saturn, lead; and the Moon, silver).

To the right is a hand-illuminated page from the 1472 printing of Naturalis Historia. By any measure, the Romans garnered a long-lasting readership.



Pliny adhered to the Oceanus theory, citing Aristotle's authority.

> *The intention of the Artificer of nature must have been to unite the earth and water in a mutual embrace, earth opening her bosom and water penetrating her entire frame by means of a network of veins radiating within and without, above and below, the water bursting out even at the tops of mountain ridges, to which it is driven and squeezed out by the weight of the earth, and spurts out like a jet of water from a pipe. This theory shows clearly why the seas do not increase in bulk with the daily accession of so many rivers. The consequence is that the earth at every point of its globe is encircled and engirdled by sea flowing round it.*

Pliny accepted Aristotle’s reversed hydrologic cycle, the proof stemming from water’s preferred shape.

> *But what the vulgar most strenuously contend against is, to be compelled to believe that the water is forced into a rounded figure; yet there is nothing more obvious to the sight among the phenomena of nature. For we see everywhere, that drops, when they hand down, assume the form or small globes.*

Pliny refers to a network of veins where,

> [Water] *pushed by blasts of air and compressed by the weight of the earth... gushes forth in the manner of a pump* [siphon] *to the highest levels.*

Pliny endorses Aristotle as to "why the sea is salt" and gives qualitative description of salinity distribution with depth:

> *Hence it is that the widely-diffused sea is impregnated with the flavor of salt, in consequence of what is sweet and mild being evaporated from it, which the force of fire easily accomplishes; while all the more acrid and thick matter is left behind; on which account the water of the sea is less salt at some depth than at the surface.*

Naturalis Historia provided a compendium of subterranean streams.

> *But some rivers so hate the sea, that they actually flow underneath the bottom of it, for instance the spring Arethusa at Syracuse, in which things emerge that have been thrown into the Alpheus which flows through Olympia and reaches the coast in the Peloponnese.*

We will see more of this Syracuse conection in Chapter 28, Et In Arcadia Ego.

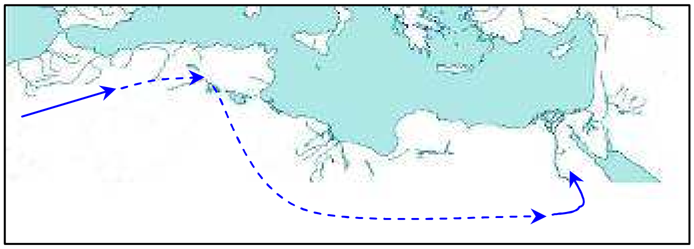
> *Instances of rivers that flow underground -- and come to the surface again are the Lycus in Asia, the Erasinus in the Argolid and the Tigris in Mesopotamia; and objects thrown into the Baths of Aesculapius at Athens are given back again in Phaleron Harbor* [about 10 kilometers distant]. *Also a river that goes underground in the Plain of Atinas* [in modern Turkey] *comes out 30 kilometers further on, as also does the Timavus in the district of Aquilea.*

We will see more to the Timavus connection in Chapter 72, Underground and Balkanized.

Pliny observed an underground river from Lake Vadimo in Etruria (modern Tuscany), the scene a 310 BC battle.

> *The water is sky-blue; its smell is sulfurous, and its flavor has medicinal properties, and is deemed of great efficacy in all fractures of the limbs. This lake empties itself into a river, which, after running a little way, sinks underground, and, if anything is thrown in, it brings it up again where the stream emerges.*

The Nile originates "in a mountain of lower Mauretania," flows above ground for "many days," again flows underground, reappearing as a large lake in the territories of the Masaesyli, then sinks once more below the desert to flow underground "for a distance of 20 days' journey till it reaches the nearest Ethiopians."



We'll return to this subterranean route in Chapter 71, Sub-Saharan Streamflow and Shambhala, but let us here note that the source of the Nile would baffle geographers for another two millennia, as evidenced by The Earth: A Descriptive History of the Phenomena of the Life of the Globe (1871) by Elisee Reclus.

> *The Nile does not receive a single visible affluent; nevertheless, it must necessarily be replenished by several underground tributaries, for its liquid mass is much more considerable in Egypt than in Nubia.**

Pliny the Younger (61-114) reported that his uncle, commanding the fleet at Misenum, ordered his ships to cross the Bay of Naples for a first-hand look at Mt. Vesuvius where the fumes and ash became so strong that they suffocated him.

Considering the consequence of Pliny the Elder's field trip, perhaps we should be less harsh on the encyclopedists who worked from their offices in Rome.

A spring near Como said to ebb and flow three times a day was mentioned by the younger Pliny in a letter written between 98 and 108 AD. He suggested several explanations:

a) Glugging, as in a bottle being emptied.

b) The influence that causes tides in the sea.

c) In the way that a river may be hindered by wind and tide.

d) A subterraneous "poise" [balance or equilibrium], valve-like, that when the reservoir is dry allows the spring to operate, but when full, chokes it.

e) *Or is there rather a certain reservoir that contains these waters in the bowels of the earth, which while it is recruiting its discharges, the stream flows more slowly and in less quantity, but when it has collected its due measure, it rises again in its usual strength and fullness.*

This last explanation might be a siphon, the subject of Chapter 44, but Pliny did not understand the mechanism.

Pausanias (110-180) left us his Descrittione della Grecia di Pausania, the original travel guide. A 1593 edition is shown to the right.

DESCRITTIONE
DELLA
GRECIA,
di Pauſania.
NELLA QVALE SI CONTIENE
l'origine di eſſa, il ſito, le Città, la Religione antica, i coſtumi, & le guerre fatte da que' Popoli.
INSIEME CO' MONTI, LAGHI,
Fiumi, Fontane, Minere, Statue, Coloſſi, Tempii, & tutte le coſe meravigliose, che l'hanno illuſtrata.
Tradotta dal Greco in volgare dal S. Alfonſo Bonacciuoli Gentilhuomo Ferrareſe.

Al Ser.mo Sig. il S. Donno Alfonso
d'Eſte Duca di Ferrara, &c.

IN MANTOVA,
Per Franceſco Oſanna Stampator Ducale.
M D X C I I I.

Pausanias traveled to Arcadia, famous for its closed depressions and perennial springs, where he noted the river Styx.

Pausanias repeated with more topographical detail Strabo's information on the Stymphalus, the combined origin of the Alpheius and the Eurotas, and the further course of the Alpheius to Syracuse.

He recorded an occasion when drifted timber blocked the sink at Stymphalus and the plain became a lake for a width of 75 kilometers. A huntsman following a deer into the marsh was said to have caused the blockage to break apart and be drawn into the sink.

We'll return to Arcadia's depiction in poetry in Chapter 28.

Pausanias wrote that the Helicon River, after a course of 13 kilometers disappears into the earth at the foot of Mt. Olympus and after another 4 kilometers, rises again as the Baphyra, navigable to the sea. Legend told that the women who killed Orpheus wished to cleanse the bloodstains and the river sank underground to avoid being an accomplice.

We're unsure to which modern stream this refers, but modern classicists never stop searching. Pausanias recorded an Arcadian cave in which was lost to history until 1964, but more fundamental than geographical modernity is this segment from Pausanias' sojourn in Epirus,

> *Near Cichyrus is a lake called Acherusia, and a river called Acheron. There is also Cocytus, a most unlovely stream. I believe it was because Homer had seen these places that he made bold to describe in his poems the regions of Hades, and gave to the rivers there the names of those in Thesprotia.*

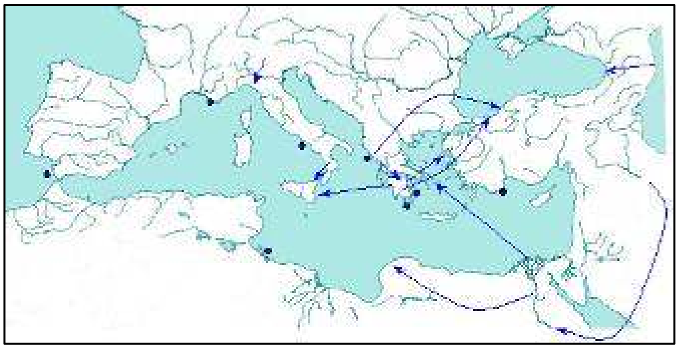
It's Pausanias' hat-tip to Homer.

The geographer Eratosthenes supposed that the Egyptian marshes of Rhinosoloura between the Mediterranean and the Red Sea were formed by the Tigris and Euphrates, 1,000 kilometers away.

Following are other Mediterranean-basin rivers said to disappear and re-emerge at locations locatable on modern maps.

Reported Disappearance	Reported Reappearance
Arcadian Alpheus entering 2 kilometers of bushy wetlands at the Ionian Sea. We'll revisit the lore of Arcadia in Chapter 28.	Arethusa Spring near Syracuse, Sicily, or alternatively, on the Aegean island of Tenedos, south of the Dardanelles.
Asopus flowing through Sicyon, northwest of Corinth	Both Boeotia of modern Greece and Anatolia of modern Turkey.
Inachus in Epirus	Peloponnesus.
Waters in Italy	Sicilian springs
The turbid Acheron in Epirus	Acheron at Hercales Pontica (modern Eregli, Turkey), seen by the Argonauts
Caspian Sea	Black Sea
The Jordan at the Dead Sea	
"Lost rivers" in western Spain.	
The Tigris near its source in Anatolia	

The map traces some of the reported subterranean connections. Dots mark reported submarine springs tabled below.



Reported Submarine Springs

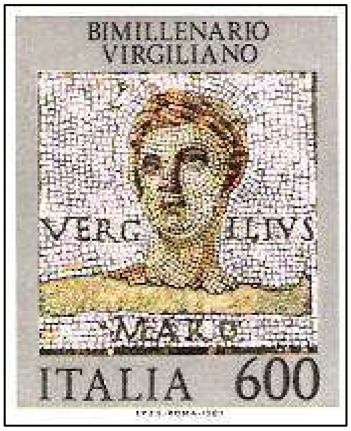
Dulcis Portus on the west coast of Epirus
Spring of Deine in the Argotic Gulf.
Cape Matapan, the southernmost point of Peloponnesus, perhaps a version of the actual cavern discharge at Pirgos Diru.
Between the island of Aradus and the Phoenician mainland, 2 miles off the coast from Tripoli.
Between Baia and Ischia (island west of Naples) or near Pozzuouli, near Naples
Off the coast of Lycia on the southwestern Turkish Anatolian coast.
Côte d'Azuris or 20 kilometers southeast of Marseille
Near Cadiz in the Atlantic.

We'll return to such sites in Chapter 42, Submarine Springs and Submarine Rivers.

The table below illustrates the spectrum of speculation about the Nile.

Reported Disappearance	Reported Reappearance
The Antichthon (the opposite hemisphere)	Ethiopia
Three North African streams	Spring on Mt. Atlas
The Euphrates in a Mesopotamian marsh	The Nile beyond Ethiopia
Crocodile-infested lake, Mauretania, W. Africa	Nile headwaters in 20 days
The Nile in a highland lake	Lower Ethiopia
The Nile	Inopus in Delos, a sacred island in the Cyclades
Lake Moeris, Nile Valley	Fountain of Apollo, Cyrene, Libya, or alternatively, in Sidra

The Fountain of Apollo still gushes from a tunnel hewn into rock as it did before the birth of Christ.



Publius Vergilius Maro (70-19 BC) is better known as Virgil. Although his Georgics (29 BC) refers to rivers which issue from caverns as homes to Nymphs, we include this Roman in our study of underground rivers for his contribution of the Aeneid (19 BC), a tale written in praise of the Roman state.

Unlike the encyclopedic works we've cataloged above, the Aeneid is but a story. But in with the encyclopedic works, it's not particularly original. In fact, it's but a re-spin of... -- well, take a guess.

The Aeneid begins with Aeneas' escape during the Trojan War and follows his descent into an underworld of river familiar to us. And whom do we meet? Charon, the curmudgeonly ferryman!

That will be two obols, sir.

The Aeneid parallels the Odyssey in structure, Romanizes the characters and expands upon the incidents, but it's Homer's saga. Here's Virgil's Charon in verse.

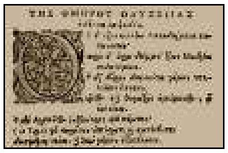
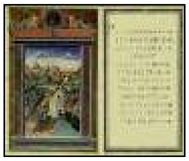
> *There Charon stands, who rules the dreary coast --*
> *A sordid god, down from his hairy chin*
> *A length of beard descends, uncombed, unclean;*
> *His eyes, like hollow furnaces on fire;*
> *A girdle, foul with grease, binds his obscene attire.*

As noted earlier in this chapter, both Strabo and Pliny spoke of the subterranean Timavo River. So does the Aeneid. From Edward Fairfax Taylor's translation

> *Safe could Antenor pass the Illyrian shore*
> *Through Danaan hosts, and realms Liburnian gain,*
> *And climb Timavus and her springs explore,*
> *Where through nine mouths, with roaring surge, the main*
> *Bursts from the sounding rocks and deluges the plain.*

We will wait until Chapter 72, however, Underground and Balkanized, to pull the Roman accounts into geographical relationship.

In the manner of the table in Chapter 1,

	 Odyssey (c. 855 BC)	 Aeneid (19 BC)
Author	Homer	Virgil
Protagonist	Odysseus	Aeneas
Setting	Mythical Mediterranean, mythical times	
Opening	*Tell me, O muse, of that ingenious hero who travelled far and wide after he had sacked the famous town of Troy.*	*Arms, and the man I sing, who, forc'd by fate, and haughty Juno's unrelenting hate, Expell'd and exil'd, left the Trojan shore.*
Characters	Lotus Eaters Cyclops Sirens	Odyssey survivor's tale
Rivers	Acheron Cocytus	*To deep Acheron they take their way, whose troubled eddies, thick with ooze and clay, are whirl'd aloft, and in Cocytus lost.*
	Styx	Between the living and dead.
	Lethe	On the far side, Aeneas' descendants
	Pyriphlegethon	

By the late third century, Rome was intellectually spent, the Empire having spun itself into two segments, the western half to be the foundation for the European Middle Ages and the eastern half to become the Byzantine Empire.

But before advancing to Chapters 4-6 to see what became of the Greco-Roman legacy, let's summarize our journey to this point.

> Greek mythology laid down a rich lore of underground rivers.
> Greek philosophers molded the tales into explanatory patterns based on reason.
> Roman encyclopedists dutifully cataloged numerous instances of such waters.

One might think that the topic of underground rivers is now resolved, but the Greeks and Romans were just feeding our curiosities.

CHAPTER 4
THE CROSS

In this and the next two chapters we will chronicle

- The first millennium. How the nature of underground rivers fell into the domain of Christian theology.
- The change of millennia. How Greek thought regarding such waters was preserved by the Arabs.
- The early second millennium. How the Church reinterpreted what flows beneath the earth.

To begin, we'll summarize the Christian interpretation's Hebrew formulation in an environment where water and cultural destiny intertwine. The tribe controlling the water sources is the tribe that survives.

The Book of Genesis

As would have most early Christians addressing the workings of nature, we'll start with Creation,

The world's water originated within the earth, as chronicled in Genesis 2:6.

> *But there went up a mist from the earth, and watered the whole face of the ground.*

The "mist" is "ed" in Hebrew which also means flow, stream or spring. Etymology points to the Sumerian/Akkadian "id," the cosmic river, as in "from the mouth whence issues the waters of the earth and brought her sweet water from the earth," in the Sumerian story of Enki and Nihursag.

Genesis 2:10-14 enumerates what have come to be known as the "Four Rivers of Life," the Pison, Gihon, Hiddekel and Perath.

> *And a river went out of Eden to water the garden; and from thence it was parted, and became into four heads.*
> *The name of the first is Pison: that is it which compasseth the whole land of Havilah, where there is gold;*
> *And the gold of that land is good: there is bdellium and the onyx stone.*
> *And the name of the second river is Gihon: the same is it that compasseth the whole land of Havilah* [Ethiopia].
> *And the name of the third river is Hiddekel: that is it which goeth toward the east of Assyria. And the fourth river is the Perath.*

The Hiddekel and the Perath are likely the Tigris and Euphrates. As "Havilah" means "stretch of sand," the Gihon is associated with desert and thus might be the Nile. (Jerusalem's Gihon Springs -- which we'll visit in Chapter 59, Subterranean Aqueducts -- was named from the Genesis story, not the other way around.)

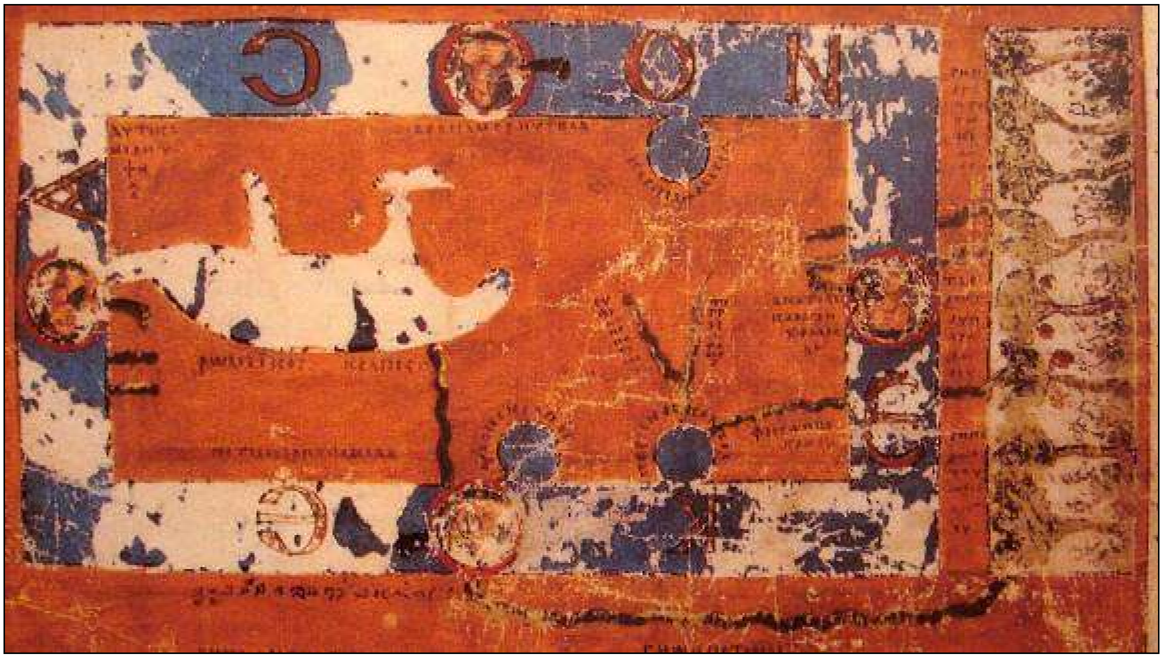
The modern identity of the Pison is disputed. The Ganges, the Araxes and the Uizhun have been proposed as well as the now-dry Wadi Bisha in Kuwait. Early Syriac commentators endorsed the Danube. The Jewish scholar Nahmanides thought the Pison to be the Indus.

While the Book of Genesis makes no assertion that any of the rivers flowed underground, the logic for such a pathway would seem sound. How but by a subterranean route could the four rivers get from the Garden of Eden to their respective surficial headwaters?

Topographia by Cosmas Indicopleustes, a sixth-century Christian merchant, describes the Red Sea and the Indian Ocean including fountains which "cleave a passage through the ocean and spring up in this earth."

> *Divine scripture, with a view to show the diameter of Paradise, how great it is, and how far it extended eastward, mentions the four rivers only, and thence we learn that the fountain which springs up in Eden and waters the garden, distributes the residue of its waters among the four great rivers which cross over into this earth and water and a large part of its surface.*

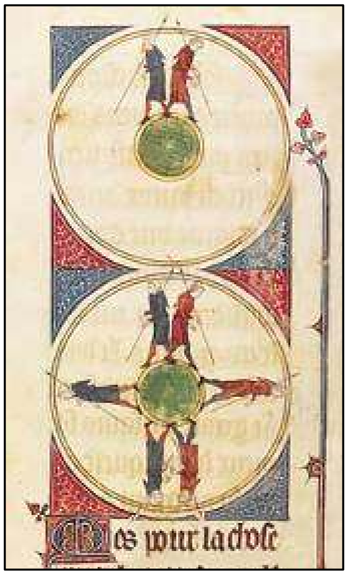
Cosmas maps the Tigris, Euphrates and Pison as three fissures from Paradise (the rectangle on the right of the figure below) to the Persian Gulf (the right-most circle on the rectangular earth). The Gihon, the blue pathway along the map's bottom, flows from Paradise to the Blue Nile's headwaters at Gish Abay Mikael, Ethiopia, a photo of which is to the right.



To appreciate the persistence of the Niles's association with the Gihon, we quote from L'Image du Monde (c. 1246) by Gautier de Metz, a work based on Imago Mundi by Honorius of Autun (d. 1151) dealing with creation, the earth and the universe.

> *The second of the four flodes is named Gyon or Nylus, which entreth into the erthe by a pool, and renneth under the erthe.*

Merz described the Nile encircling Egypt and Ethiopia -- not a bad approximation from the European perspective -- and a spherical Earth (right).



Let us turn to Genesis 4:11-12.

> *And now art thou cursed from the earth, which hath opened her mouth to receive thy brother's blood from thy hand. When thou tillest the ground, it shall not henceforth yield unto thee her strength; a fugitive and a vagabond shalt thou be in the earth.*

Note the change of adverb in the chronology of translations.

King James Version	1611	in the earth
American Standard Version	1901	in the earth
Revised Standard Version	1946	on the earth
New International Version	1973	on the earth
New King James Version	1982	on the earth
21st Century King James	1994	on the earth

Are we on the earth, or are we inside it? We'll speculate in Chapter 14, Hollow Earth Geophysics.

Genesis 11:7 concerns Noah's Flood.

> *The same day were all the fountains of the great deep broken up, and the windows of heaven were opened.*

"Fountains of the deep," will come to be a favorite phrase of those striving to assign a Biblical basis to the science of hydrology.

The Book of Exodus

Subterranean waters made the Second Commandment, Exodus 20:4.

> *Thou shalt not make unto thee any graven image, or any likeness of any thing that is in heaven above, or that is in the earth beneath, or that is in the water under the earth.*

“Water under the earth” was physically known to the Hebrews. They knew of hand-dug qanats, (Chapter 59) in Armenia and Persia. Hebrew land extended to the River Jordan, the eastern source said to emerge fully-formed from an iron-red limestone cliff at the foot of Mt. Hermon.

After the Hebrews’ escape from Egypt, the refugees

> *Came to Elim where there were twelve wells of water, and threescore and ten palm trees; and then encamped there by the waters.”* -- Exodus 15:27

When the refugees needed more water, God told Moses at Mt. Horeb (modern Sinai).

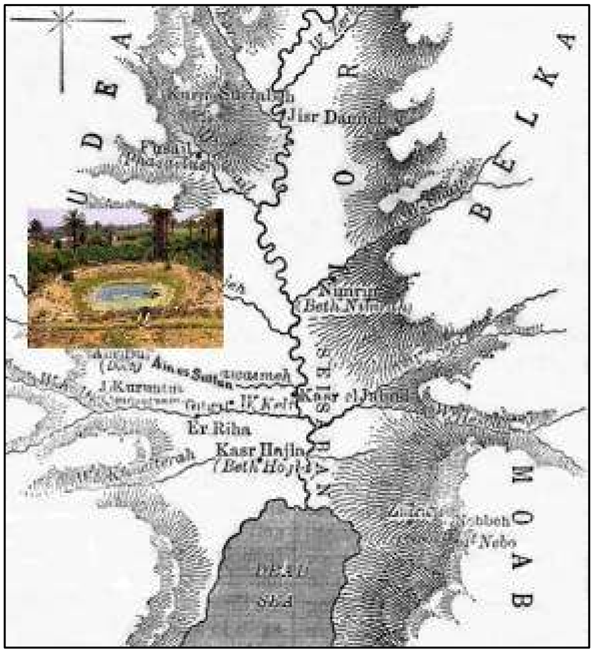
> *"And thou shalt smite the rock, and there shall come water out of it, that the people may drink.”* -- Exodus 17:6.

The Spring of Elim at Wadi Tayyib al-Ism
is said to be that water.

The Second Book of Kings

Today’s Ain-es-Sultan, the Sultan's Spring near Jericho, is the spring "healed" by Elisha’s casting of salt (II Kings 2:21) and the source of Barada (the Biblical "Abana"). Syrians still escape modern Damascus to enjoy the apricot, apple and walnut trees. According to the he International Bank for Reconstruction and Development,

> *The principal emergence of the spring, which has been enclosed in a structure since Roman times, resembles an underground river several meters across which flows up and out of the limestone formation of the mountain. The total flow has averaged 8.63 cubic meters per second.*



Jordan Valley, from The Bible Educator (1870) with overlay of modern Ain-es-Sultan

The Book of Psalms

Hebrew geography was Babylonian, the sea encircling the earth and hidden channels to “the great deep” from which all waters derive (Psalms 136:6). Hebrew/Babylonian floods came from below, not from above. The vassal-treaties of Esarhaddon declare, "May a flood, an irresistible deluge, rise from the bowels of the earth and devastate you."

The Book of Ecclesiastes

Ecclesiastes 1:7 cemented the early Christian opinion concerning underground waters.

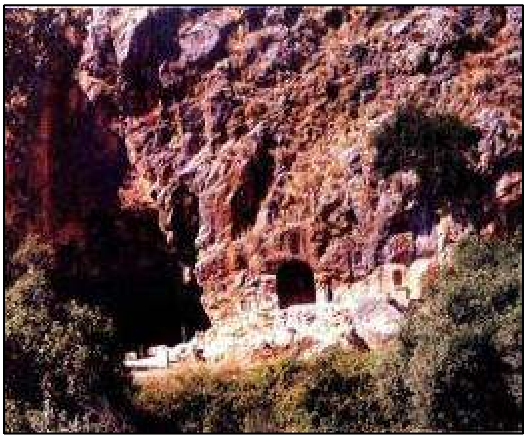
> *All the rivers run into the sea,*
> *Yet the sea is not full;*
> *To the place from which the rivers come,*
> *There they return again.*

How the rivers return is not specified, but as such conduits are not visible on the surface, it stands to reason that they must be below.

The term “rivers” of this verse is the Hebrew “nhl,” flash flows in wadies after heavy rainfall. “Nhr,” Hebrew for a river continually flowing, was not used for streams in Palestine, but was used for the Tigris and Euphrates. Ecclesiastes 1:7 speaks metaphorically of the vain course of human nature, for those seeking scriptural explanation of nature, the verse would provide 2000 years of mindset. We'll get back to metaphors in Chapter 29.

And now we must move on to the New Testament, which is to say, welcome the Greeks.

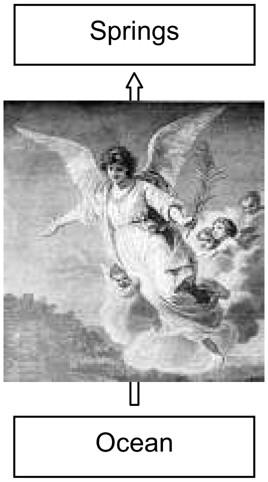
The Early Church



Jesus made what must have been an arduous trip to "the Gates of Hades" in Caesarea Philippi (Mathew 16:13), at least a full day uphill from Bethsaida. The gate was the Cave of Pan with its Paneion Springs, a 15 by 20-meter cavern which in pre-Roman times was taken to be an entrance to the underworld. King Herod built a marble edifice dedicated to Caesar at the entrance.

Reference to an underground Hell is nonexistent in the Old Testament. Hebrew tradition was not particularly concerned with questions of the afterlife; "She'ol" is where all go. To a Jew such as Matthew, "the Gate of Hades" was to a Greek Hades.

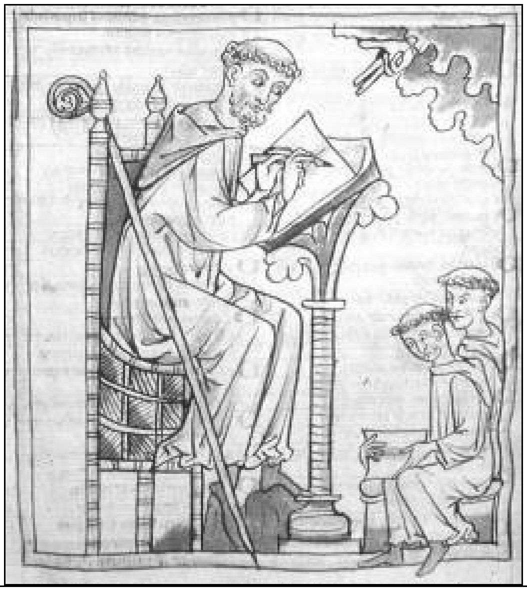
The early Christians thus advanced a hydrologic perspective based on the authority of the Hebrews, Greeks and Romans.

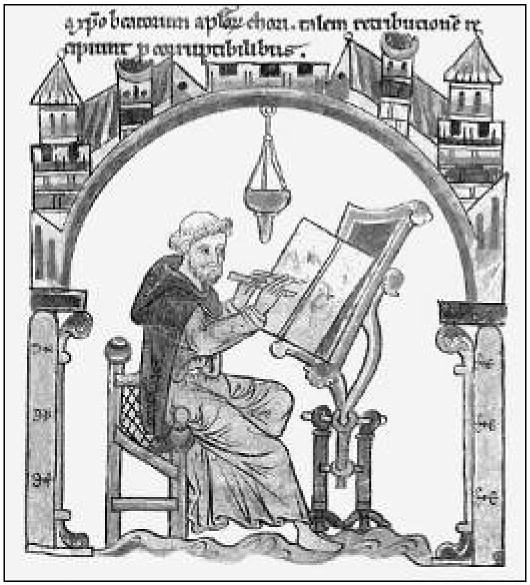


De Providentia by Bishop of Cyrus Theodoretus (393-457) instructs the faithful that water rises to the mountain tops in “obedience to the word of God.”

In the diagram to the right, it's the will of God -- angel power, we might say -- that moves waters from the sea to hillside springs. Nothing more need be said regarding the physics, as the Church had more important matters with which to deal. The noun "Agnostic," for example, is from "agnus" (lamb) and "Stygis," our very own River Styx. "Agnostic" was applied to those who thought the specific miracles of Christianity to be improvable and thus by reason of the Lamb of God, neither believing nor disbelieving, would be left stranded on the riverbank.

Emerging in the fifth century, the monastic movement was about prayer, not the workings of nature, but monastic transcriptions over the subsequent 800 years preserved medical manuals, a small portion of Plato's writings, astrological charts and Latin comprehendi making minimal distinction between myth and observation.





The scriptorium was generally situated near the monastery kitchen to prevent frozen fingers.

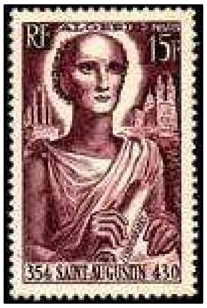
A Syrian, a Greek, a Spaniard, a Roman, a Celt and a Frank

We can catch the intellectual flavor of the era from a geographic spread of dutiful men of the cloth.

Ephraem the Syrian (306-373), a theologian of the in the Syriac Orthodox Church, had this to say in Commentary on Genesis.

> *The four rives, then, are these: the Pison, which is the Danube; the Gihon, which is the Nile; and then the Tigris and the Euphrates, between which we dwell. Although the places from which they flown are known, the source of the spring is not* [known]. *Because Paradise is set on a great height, the rivers are swallowed up again and they go down to the sea as if rivers through a tall water duct and so they pass through the earth which is under the sea into this land. The earth then spits our each one of them; the Danube, which is the Pison, in the west; the Gihon in the south; and the Euphrates and the Tigris in the north.*

To Ephraem, hydrology is a sermon and all four Rivers of Life are subterranean.



Bishop of Hippo and author of Confessions, Augustine (354-430) provided emerging Christianity a philosophical -- as opposed to purely theological -- basis. According to Augustine, Plato's acquiescence to things supernatural was well-suited for a faith based on grace. Aristotelian eternalism, on the other hand, seemed incompatible. Plato's world-view allowed divine will, while Aristotle's mechanistic arrangements constrained God's holy hand. Unlike Aristotle's "motionless mover," a Neo-Platonic cosmology featured a creator who shares his goodness from pre-existent and co-eternal matter.

To seal Plato's supremacy in matters philosophical,

> *Nothing is to be accepted save on the authority of Scripture, since greater is that authority than all the powers of the human mind.*

The meaning is simple: Believe what is told, not what is noticed. The fact that Platonic philosophy is not as conducive to the study of nature as is an Aristotelian viewpoint poses little problem a St. Augustine disinclined to study nature. Despite being translated into Latin by Boethius (475-524), Aristotle's observational -- often biological -- world-view was thus relegated to disrepute.

Although Augustine had less interest in worldly questions, his writings occasionally spilled in that direction. Consider, for example, The Works of St. Augustine: A Translation for the 21st Century (2002), edited by John Rotelle.

> *Since the actual site of Paradise totally escapes human ken, the waters from it are indeed divided into four parts, as the utterly trustworthy testimony of scripture assures us, but that those rivers whose sources are said to be known have gone underground somewhere, and after wending their way through extensive regions have gushed out in other places, where their sources are held to be known. Is anybody unaware, I mean, that there are streams which regularly do this? But it only comes to our attention where they do not flow underground for any great distance.*

Though God created but four rivers, how can we now have many? One would doubt this to be a pressing question in its own merit, but here a bishop could not concede an incomplete Holy Word. A springhead is not a source, but one of many outlets from one of four underground waterways, the good bishop instructs.

Augustine's philosophical framework would gird the evolving Church. As we will see shortly, his passing mention of streams flowing underground would likewise guide the yet-to-come science.

The Spaniard, Isidore of Seville (570-639), produced the encyclopedic Etymologies, the seminal compendium of secular knowledge of his period. More than 1000 manuscripts in length, Etymologies cataloged the seven liberal arts identified by the Roman Encyclopedist Varro (Chapter 3) plus,

V Cent° del Descubrimiento de América 1492-1992
17 correos españa

Medicine
Law
The Calendar
Theology
Anthropology (including monstrous races)
Geography
Cartography
Cosmology
Mineralogy
Agriculture

As Etymologies strove to reconcile the world with Genesis, fossils were the remains from Noah's flood.

Isidore's opinion regarding springs and rivers was that of the Pliny the Elder (Chapter 3) who in turn was repeating the Greeks.

> *Moreover that the sea does not increase, though it receives all streams and all springs, is accounted for in this way; partly that its very greatness does not feel the waters flowing in; secondly, because the bitter water consumes the fresh that is added, or that the clouds draw up much water to themselves, or that the winds carry it off, and the sun partly dries it up; lastly, because the water leaks through certain secret holes in the earth, and turns and runs back to the sources of rivers and to the springs.*

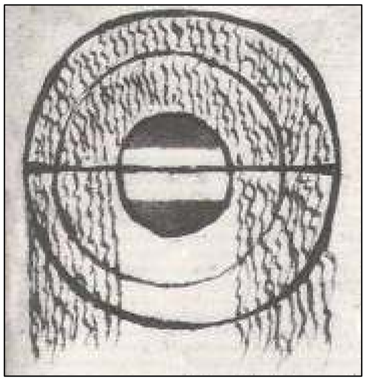
It's a wordy Ecclesiastes 1:7.

> *The abyss is the deep water which cannot be penetrated; whether caverns of unknown waters from which springs and rivers flow; or the waters that pass secretly beneath, whence it is called abyss. For all waters or torrents return by secret channels to the abyss which is their source.*

Streamflow is thus a combination of rainfall and underground "secret holes."

Ambrosius Theodosius Macrobius' (395-423 AD) had argued that if rain doesn't fall toward the earth's center -- contrary to lore regarding Columbus, scholars back to the Greeks recognized the earth to be spherical -- precipitation missing the edges must ascend toward the heavens. A scribe's illustration is to the right.

But such thought experiments were becoming lost to Platonic disinterest as unexamined pathways of nature came to be put forth as de-facto proof of physically-untestable divine law.



John the Scot (800-880) proposed in De Divisione Naturae (866) a sacred steadiness in the course of all creation. Ecclesiastes 1:7 served his argument against ungodly material progress,

> *Divine goodness... flows downward like a stream, first into the primordial causes, bringing them into being. Next, continuing downward through these primordial causes, ineffable in their workings, but still in harmony with them, they flow from higher to lower, finally reaching the lowest ranks of the All. The return flow is through the most secret pores of nature by a most concealed path to the source.*

Analogy to flow "through the most secret pores of nature by a most concealed path" may illustrate John's opinion about divine goodness, but it is one more illustration of theology intermingled with subterranean waters.

The Frank, Bernard of Clairvaux (1090-1153), a theologian of mystical bent, compared the sea to Christ.

> *The sea is the source of fountains and rivers; the Lord Jesus Christ is the source of every kind of virtue and knowledge.*

In a sermon from his Cantica Canticorum, the subterranean water course becomes an Ecclesiastic metaphor for spiritual operation.

> *If all waters seek incessantly to return to the sea, making their way thither sometimes by hidden and subterranean channels, so that they may go forth from it again in continual and untiring circuit, becoming visible once more to man and available for his service, why are not those spiritual streams rendered back constantly and without reserve to their legitimate source, that they may not cease to water the fields in our hearts? Let the rivers of diverse graces return from whence they came, that they may flow forth anew.*

Metaphor notwithstanding, Bernard bemoans his generation as dwarfs standing on the shoulders of Greek giants, unable to see farther by individual brilliance, but through mastery of the classics.

Conclusion

As fewer and fewer Europeans thought about more than basic needs and religious ritual, ancient texts were left to decompose. Instances can be uncovered of sequestered intellectualism -- we tip our hat to Macrobius -- but critical thought in large part was increasingly stifled by dogma.

The imaginative richness associated with underground rivers had faded. No one was retelling the tale of Charon, compiling novel encyclopedias, thinking about rainfall missing the earth, peering into caverns. Ecclesiastes 1:7 posed no an intellectual invitation.

Physically out of sight, intellectually out of mind, thought about underground rivers approached extinction.

CHAPTER 5
THE CRESCENT

We will see in Chapter 40, Sinkholes, how scuba divers successfully linked two systems of underground waterways to form in combination the world's longest underground river.

The Arabs of 600-1200 were likewise linkers of underground rivers, their curation being the bridge from a faltering Western legacy to the concepts we recognize today.

We should qualify our employment of the term "Arabic" in its geo-political, not ethnic, sense. Subjects of Arabic rule included Persians, Negroid Africans, Christians of many stripes, Jews and others.

The original Hebrews had no ethnic advantage in attention to water. All desert peoples accorded water cultural importance. The Shari'a, the source of Islamic law -- and thus the crux of Arabic identity -- literally means "source of water." Qur'anic verses alluding to water underground include,

> *And give glad tidings to those who believe and do righteous good deeds, that for them will be Gardens under which rivers flow. -- 2:25.*
>
> *For such, the reward is Forgiveness from their Lord, and Gardens under which rivers flow, wherein they shall abide forever. -- 3:136.*
>
> *I will remit from them their evil deeds and admit them into Gardens under which rivers flow. -- 3:195.*
>
> *But, for those who fear their Lord, are Gardens under which rivers flow. -- 3:198.*
>
> *Lo! Allah will cause those who believe and do good works to enter Gardens under which rivers flow.* -- 22:23.
>
> *He sendeth down water from the sky, so that valleys flow according to their measure.* -- 13:17.
>
> *And We* [Allah] *have placed therein gardens of the date-palm and grapes, and We have caused springs of water to gush forth therein.* -- 36:34.
>
> *Hast thou not seen how Allah hath sent down water from the sky and hath caused it to penetrate the earth as water springs?... Lo! Herein verily is a reminder for men of understanding.* -- 39:21.
>
> *If all your water were to disappear into the earth, who then could bring you gushing water?* -- 67:30.

The degree to which ancient texts lend themselves to modern interpretation is a never-ending challenge.

Consider, for example, "tajri min tahtiha al-anhar," the Arabic phrase common to the above texts translated as "under which rivers flow." In contextual Arabic, the phrase suggests rivers running through gardens surrounding an elevated dwelling, the palaces of Paradise in this case. Shehzad Saleem addresses our question directly in "Will Paradise have Underground Rivers?" Renaissance, January 2012.

> *In order to understand the Qur'anic description of Paradise, it may be noted that the Arabs of the times of the Prophet (peace and mercy upon him) had a special taste regarding gardens. To them, the most scenic of gardens and orchards were those which were situated at some height above the ground level on some mountain or hill such that rivers and streams would flow around and beneath them at a lower altitude. The height not only adds to the beauty of the orchard, but also secures it from floods and similar calamities.*

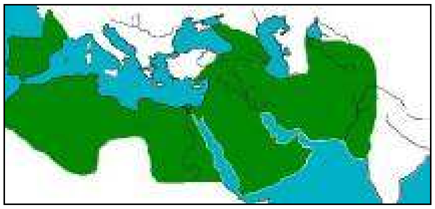
> *Thus the words do not mean that the gardens of Paradise would have underground rivers. The words here signify a relative lower altitude of the rivers and not their being underground. The following verse portrays such a garden,*
>
>> *And the likeness of those who spend their wealth, seeking to please Allah and to strengthen their souls is as a garden high and fertile: heavy rain falls on it but makes it yield a double increase of harvest, and if it receives not heavy rain, light moisture suffices it. Allah sees well whatever you do. (2:265)*
>
> *At another place, the Qur'an has mentioned the various types of rivers that will flow in Paradise:*
>
>> [Here is] *a description of the Paradise which the righteous are promised: in it are rivers of water incorruptible; rivers of milk of which the taste never changes; rivers of wine, a joy to those who drink; and rivers of honey pure and clear. (47:15)*

Paradise, we are thus informed, thus does not necessarily include underground rivers.

But our debt to Islam isn't the answer to that question, had it occurred to us to wonder. The debt is much greater; it's for preserving the Hellenistic roots of Western culture.

A side-by-side timetable helps tell the story. The political events highlight the rise and fall of Arabic influence. The intellectual events relate to the stewardship of Greek understanding.

Highlights of Middle Eastern Political and Intellectual History

	Political Highlights	Intellectual Highlights
476	Fall of Rome	
489		The Persian school of Jundishapur gives refuge to Nestorian Christians.
529		Refuge given to those from Plato's Academy
c. 610	Muhammad receives first vision.	
630-642	Muslims capture Mecca. Arabia vows allegiance to Islam. Arab armies take Egypt, Syria, Palestine, Mesopotamia, North African coast and portions of Persia and Byzantium.	
710	Arab armies invade Spain from North Africa.	
732	Battle of Tours thwarts northward Arabic advance.	
c. 750	Maximum extent of Arabic Empire 	
Late eighth century		Persian, Greek and Jewish scholars in Baghdad begin translating classical Greek works into Arabic. The center of intellectual thought passes from Europe to the Middle East

822	.	Caliph al-Ma'mun founds the Bayt al Hikilometersah (House of Wisdom), a center for the translation of philosophical and scientific works from Greek to Arabic.
Ninth and tenth centuries		Revival of learning at Constantinople
981-1037		Persian physician ibn Sina, known to the Wwest as Avicenna
1060-1087		First systematic translation of Arabic texts into Latin by Constantine the African at Mt. Cassino, Italy
Mid 11th century	Apex of the Arabic Golden Era	
1096-1099	Crusaders conquer Jerusalem and establish principalities along the eastern Mediterranean.	
1125-1200		Translation of Aristotle from Arabic into Latin by Spanish Jews, a high point for multiculturalism.
1126-1298		Iberian-Arab Ibn Rushd, known to the West as Averroes
1187	Crusaders defeated near Jerusalem and Crusader enclaves begin to crumble.	
1453	Ottoman Empire captures Constantinople, renaming it Istanbul, and continues to expand until the Turks control much of the Middle East.	
1492	Christians reclaim Granada, expelling Muslims and Jews.	

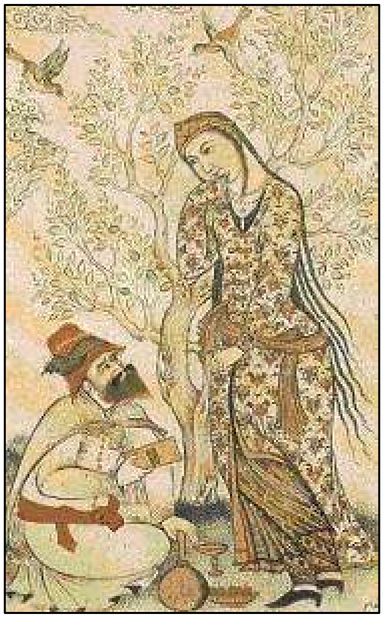
As the Dark Ages enshrouded the West, the eastern world was in ascent and Arabic scholarship was free to procure what seemed worthy. Core to our timeline are the right-hand entries flagging Greek works and ideas preserved by Arab institutions. Knowledge from many vassal states would have been archived, of course, but much of it would have faded from interest.

But the dustbin was not the fate of the Greco-Roman collection. Hebrew scholars, also "People of the Book," were welcomed into the caliphs' courts to sort through the intellectual booty.

Had Islam not been politically secure and able to afford intellectual diversity, pagan myths of underground rivers might have been discarded from translations of Aristotle. This is not to imply that the Arabs believed the Greek, but they recognized the meaning of Charon. Had not the Arabs been actively constructing a philosophy compatible with Islam, questions posed by the Greeks would not have been weighed.

Ecclesiastes 1:7 isn't Qur'anic, but the Hebrew question wasn't particular to a single race.

Particular to our interest in underground rivers are two Arabs named in the timeline.



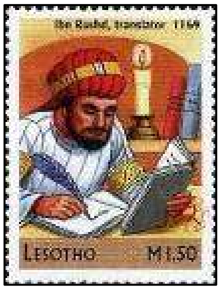
As a reward for curing his ruler's illness, Avicenna (981-1037) was allowed use of the Royal Library of the Samanids and from such study, wrote at least 400 works, the most important being the Book of Healing and the Canon of Medicine. Exceeding its title, the first was based on Euclid's Elements and dealt with logic, natural sciences, psychology, mathematics and music. The second became the most famous volume in the history of medicine, the source book for Renaissance practitioners.

Although the drawing shows Avicenna getting wisdom from a muse, most of his knowledge began in the library.

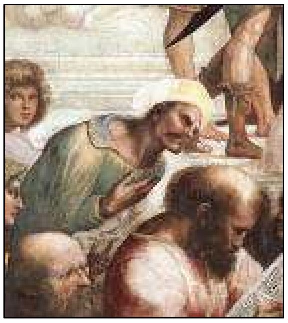
Avicenna considered a question similar to one asked by Aristotle. If nature continually erodes material from the mountains to the sea, what then regenerate the continents? Avicenna concluded that the forces of earthquakes and volcanoes recreate the land, in the process moving marine fossils to mountain tops. Presumably seeing a relationship with the period of the zodiac, he estimated the cycle of erosion and regeneration to be 36,000 years.

Avicenna's reiterated Aristotle's picture of river-perforated terrestrial subsurface. When 500 years later when Europe would at last look at geology, Avicenna's Aristotelianism would be a point from which to begin.

We'll note ibn Rushd (Averroes, 1126-1198), a Muslim from Cordoba, not for a particular pronouncement regarding our underground rivers, but for recognizing the fallacy in forcing physical insight into a mould of theological preconception. Averroes sought to integrate the more profound aspects of Islam with Greek thought, his Grand Commentaries advocating the principle of twofold truth: religion for the unlettered multitude and philosophy (Aristotelian tinged with Neo-Platonism) for the chosen.



Lesotho postage stamp, 1999. Averroes translating Aristotle.

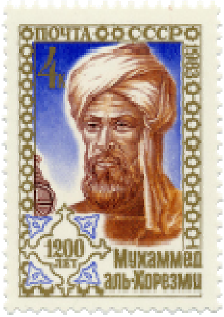


As an aside, we'll revisit Raphael's famed "School of Athens," the painting mentioned in Chapter 2 with reference to its two central figures, Plato and Aristotle. To the left, looking over shoulder of Pythagoras, is Averroes.

At least many scholars think the turbaned scholar to be Averroes. The argument to the contrary rests on the fact that he's grouped with Pythagoras, not Aristotle himself. Individual identity perhaps matters little; the overarching point is Raphael's attribution to Arabic membership in the glorified Athenian tradition.

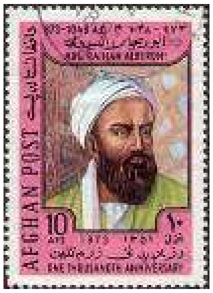
The Extraction of Hidden Waters to the Surface by Persian mathematician Al-Karaji (953-1029) distinguishes between phreatic, confined and perched groundwater. Without reference to hydrostatic pressure, Al-Karaji properly interpreted the physical basis for springs and artesian wells. He recognized the hydrologic cycle.

> *The transformation of water into air in the hot regions and air into water in the cold regions creates a constant cycle which guarantees the prosperity of the lands.*



Soviet postage stamp, 1993

Astronomer and geographer Al-Biruni (973-1048) was more explicit, explaining water level in springs and artesian wells by the principle of water finding its own level via interconnecting subterranean channels.



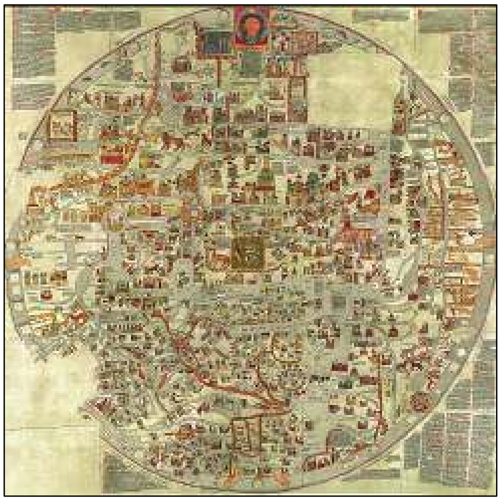
Afghan postage stamp, 1973

The Islamic contribution to the study of underground rivers was thus twofold.

> Unlike Christian appropriation of Hebrew scriptures, Qur'anic text lent itself to interpretation consistent with what we now know as the hydrologic cycle
>
> Islamic scholarship freed natural philosophy from theology. Speculation about underground rivers hinged on logic and experience, not revelation. As we will see in the chapter to come, such allowance would likewise come in the West, but more slowly and with more disputes.

At its climax, Islamic scholarship had surpassed Greek learning in many fields and created new branches of mathematics and natural philosophy. But with the beginning of the second Christian millennium, religious and political forces began to call us again westward.

CHAPTER 6
AND BACK TO THE CROSS

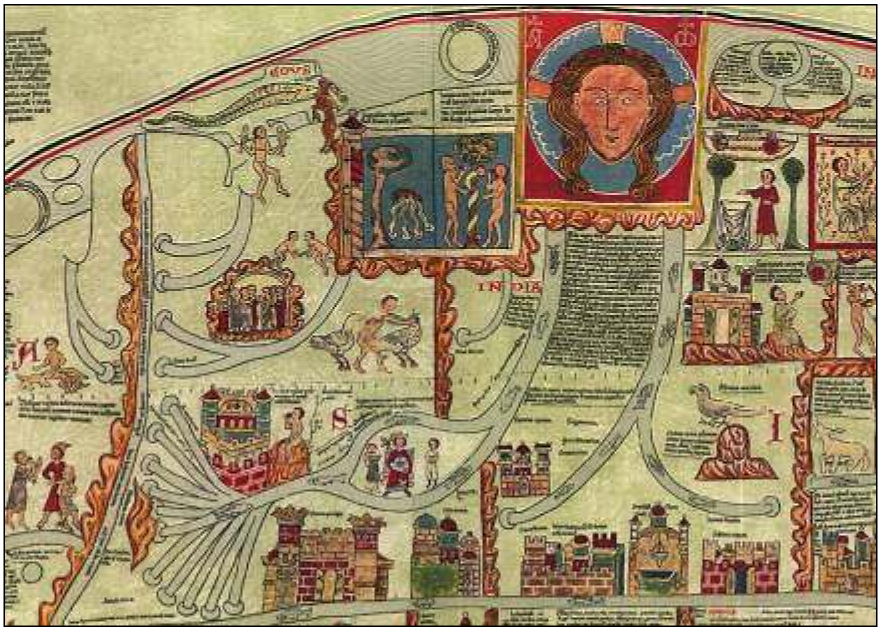


How was the world viewed through Western eyes as Christondom moved into its second mellenieum?

To the right is a copy of the Ebstorf Map (c. 1234) of Gervase of Tilbury (c. 1150-1228). East is to top

At the heart of the world lies Jerusalem, but our focus is the map's top, the detailed shown below. The Garden of Eden is guarded by towering mountains under which flow the four rivers of Paradise, of which the Pison splits into eleven tributaries of the Ganges.

Although many lands had been discovered since the founding of the Church, the metaphysical world view wasn't that different.



Aristotle's Meteorologica was translated from Arabic to Latin before 1200, but the Church was adverse to Islamic interpretation of a pagan philosopher. As we will see in Chapter 13, Hydrotheology/Theohydrology, Christendom would be heavy-handed in classical reincorporation for centuries yet to come, but at last the intellectual gate was re-opening.

Advocates of a more-pragmatic Christian world made known their challenge to Aquinas' tilt toward Plato. The fundamental challenge wasn't one of science, of course, as science hadn't been invented; it was one of theology.

To make Aristotle acceptably-Catholic -- to the Philosopher’s post-mortem protest, we must assume -- took an agile most.

Thomas Aquinas (1227-1274) saw Aristotle's Prime Mover as a foundation for Christian thought and Aristotle's pragmatic world as better suited to God's will than the hazy world of Plato.

Aquinas thus came to regard Aristotle as the greatest of philosophers unexposed to revelation.

S. TOMMASO D'AQUINO
L. 50
SAN TOMMASO D'AQUINO
S. TOMMASO D'AQUINO
L. 220
POSTE VATICANE
POSTE VATICANE L. 90
POSTE VATICANE

Aquinas sought to prove that God did not violate natural law, and thus, sensory experience. While some aspects of reality may not be accessible to rational thought, Aquinas exuded confidence in the ability of reason to describe observable events and thus come to an improved understanding of God.

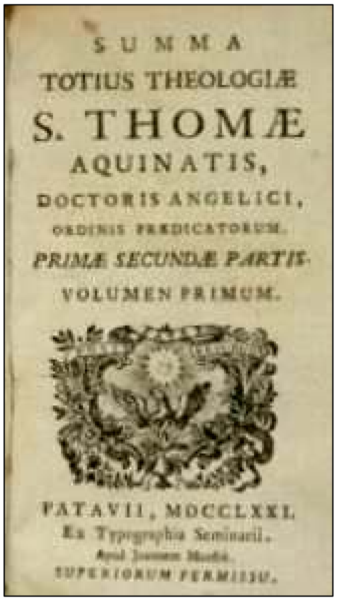
Aquinas used a form of medieval argument known as scholasticism, first stating the arguments against, then for, the side he wishes to defend, and then pointing out the arguments in favor and the weaknesses for the other side.

Aquinas' Summa Theologiae (1265-75) presented Aristotle so formidably that subsequent scientific realizations came to be criticized simply because they were not penned by Aristotle himself.

Less fundamental in theological/philosophical perspective, but most pertinent to our underground river journey, would be Aquinas' regard of the Edenic rivers,

> *It is supposed that since the site of Paradise is far removed from the knowledge of men... The rivers whose sources are said to be known have gone underground and after traversing vast distances have issued forth in other places... That some streams are in the habit of doing this is something that everybody knows.*

Aristotle had admitted his proposition of subterranean streamflow to be a Hellenist pass-along, not a verified fact and certainly not a metaphysical principal. Aquinas does much the same, blithely kicking forward the thoughts of the trusted Greek.



SUMMA
TOTIUS THEOLOGIÆ
S. THOMÆ
AQUINATIS,
DOCTORIS ANGELICI,
ORDINIS PRÆDICATORUM.
PRIMÆ SECUNDÆ PARTIS
VOLUMEN PRIMUM.

PATAVII, MDCCLXXI.
Ex Typographia Seminarii.
SUPERIORUM PERMISSU.

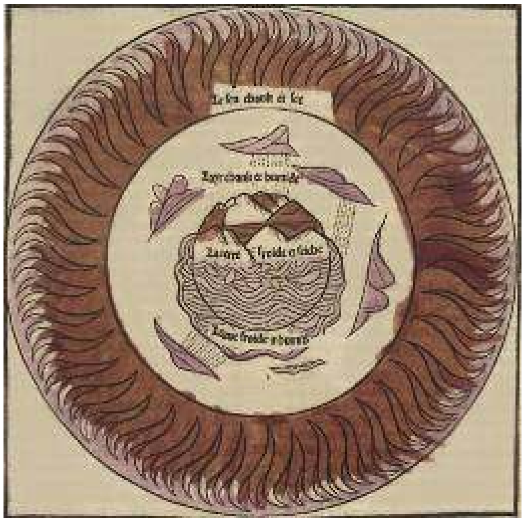
The concluding line, "That some streams are in the habit of doing this is something that everybody knows," tells all. Aquinas takes the pronouncement for granted, common knowledge. The intellect of St. Aquinas, the progressive theologian, is directed toward more lofty subjects.

The Condemnation of 1277, proclaiming divine will as sufficient explanation for all phenomena, was the conservative's last attempt to stifle Aristotelian heresy, but for reasons both pragmatic and intellectual -- but not what we can call scientific -- the Condemnation was repealed in 1325. Aristotelianism provided theology a garb of objectivity and had become Vatican dogma, at least where it didn't blatantly contradict biblical wording.

In issues of biblical wording, however, there could be but one interpretation.

Bartholomaeus Anglicus (c. 1250) acknowledged that the sun could evaporate some water from the sea or that the winds might skim water off its surface but the chief cause of streamflow lay in the subterranean connections. From a 1470 English translation of his De Proprietatibus Rerum,

> *The fresh water than rains into the sea is consumed and wasted by the heat of the sun until it becomes food and nourishment for the sea's salinity. But Ecclesiastes, the maker of waters, says that they* [the waters] *come again in secret veins of the earth to the well heads and out of the mother that is the sea, welling and springing out in well heads.*


Le feu chault et sec
Lair chault et humide
La terre froide et seiche
Laue froide et humide

Ecclesiastes 1:7 explains all that requires explanation.

More than any cleric, however, it was Dante Alighieri (1265-1321), a poet astute in the theo-politics of his day, who brought classical lore into line with pious orthodoxy. Dante saw Christian mores in Greek legend.

Where Odysseus sported quasi-god-like qualities, Dante's Inferno (1314) follows the quest of a mortal through the levels of hell in accord with the ideas of the medieval Church.

UNITED 5¢ STATES

CARY'S DANTE

Herman Melville's copy

Within an ancient mountain ("Dentro dal monte") of Crete stands the broken statue of an old man who foreworns Dante and his companion Virgil of the rivers below.

> *"Their course falls from rock to rock into this valley. They form Acheron, Styx and Phlegethon, then, by this narrow channel, go down to where there is no further fall, and form Cocytus: you will see what kind of lake that is: so I will not describe it to you here."*
>
> *I said to him: "If the present stream flows down like that from our world, why does it only appear to us on this bank?"*
>
> *And he to me: "You know the place is circular, and though you have come far, always to the left, descending to the depths, you have not yet turned through a complete round, so that if anything new appears to us, it should not bring an expression of wonder to your face."'*
>
> *And I again: "Master, where are Lethe and Phlegethon found, since you do not speak of the former, and say that the latter is formed from these tears?"*
>
> *He replied: "You please me, truly, with all your questions, but the boiling red water might well answer to one of those you ask about. You will see Lethe, but above this abyss, there, on the Mount, where the spirits go to purify themselves, when their guilt is absolved by penitence."*

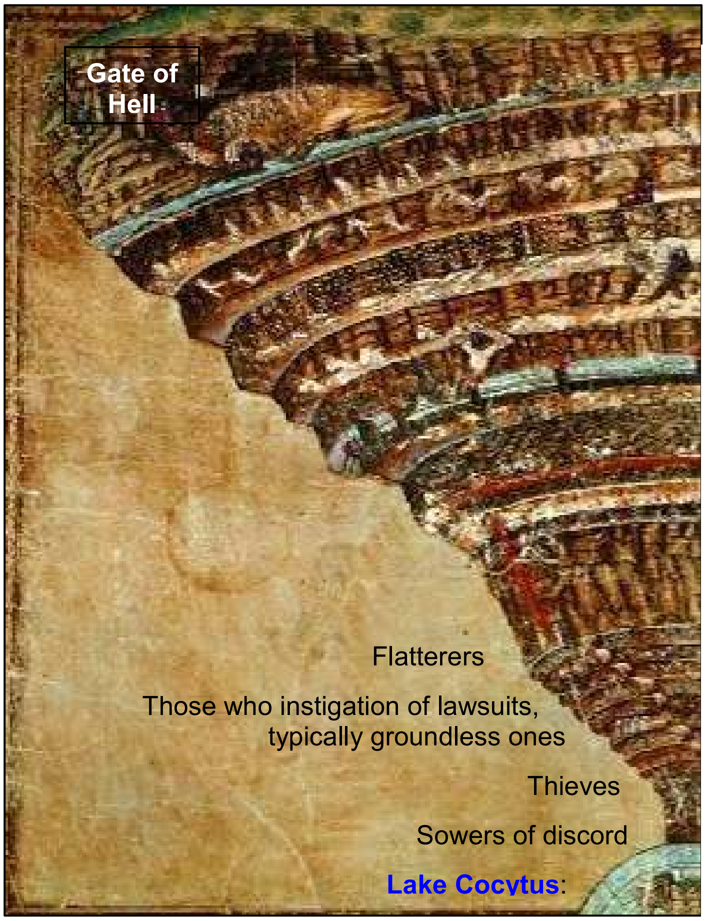
Dante's Lethe, we find, isn't beneath his feet; it's a cleansing stream in Paradise. (Similar translocation of a stream from the underground would be declared by H.M. Howell, "Christian Educator," author of The Kosmic Problem Solved (1895), who placed the Edenic rivers within the caves and chasms of ancient Greece. The Pyriphlegethon, however, being of fire and not suitable for a Christian Educator's Eden, was excluded.)

That there is a measurable difference between body and the soul is made clear when the Stygian boatman denies Dante passage because of the weight of his body.

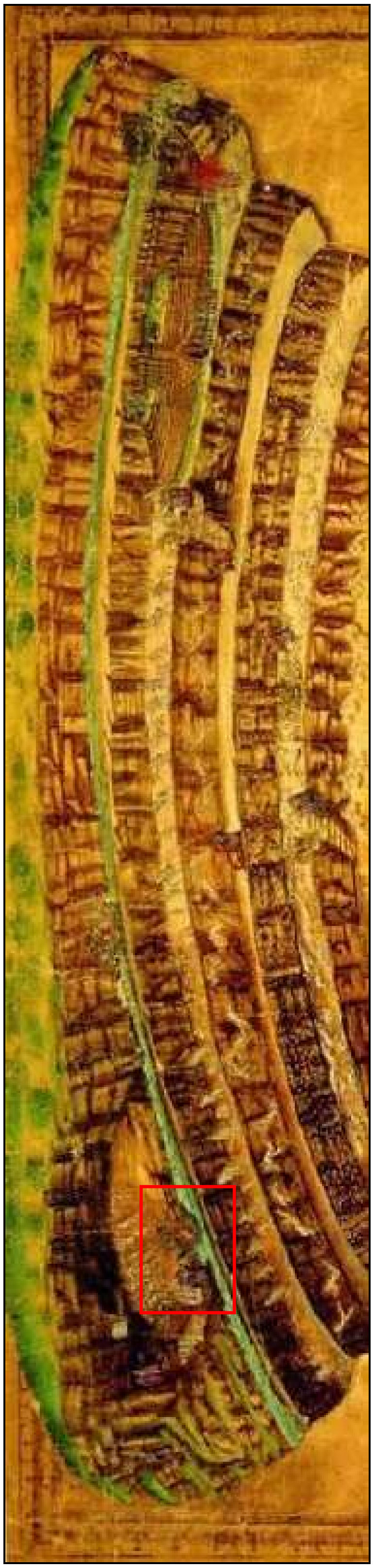
To catch the flavor of Dante's poetry, below are excerpts from three English translations.

	Longfellow (1867)	Cary (1805)	Mandelbaum (1982)
Acheron	*Upon the dismal shore of Acheron*	*Beside the woeful tide of Acheron*	*The melancholy shore of Acheron*
Styx	*A marsh it makes, which has the name of Styx*		*Forming a swamp that bears the name of Styx*
Pyriphlegethon	*The river of blood, within which boiling is whoe'er by violence doth injure others*	*The river of blood approaches, in the which all those are steep'd*	
Cocytus	*Thereby Cocytus wholly was congealed*	*Cocytus to its depth was frozen.*	*And all Cocytus froze before those winds*

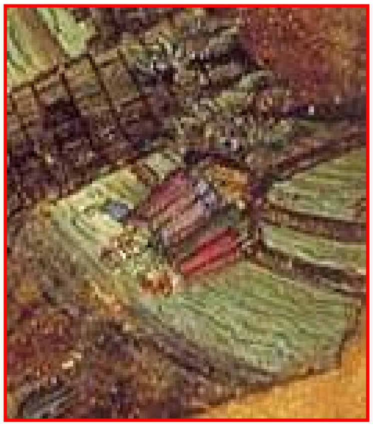
Below is half of Sandro Botticelli's circa-1480 Inferno illustration with sins ranked by depth.

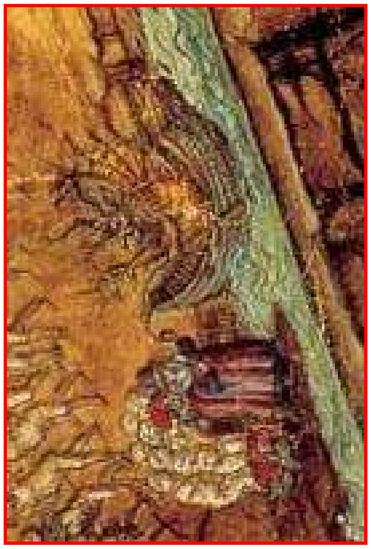

Gate of Hell
River Acheron
Virtuous unbaptized
Lustful
Gluttonous
Hoarders and squanderers
River Styx
Walls of the City of Dis
River Phlegethon
Wood of Suicides
The Abominable Sand
Panderers and seducers
Flatterers
Those who pay for sacraments and holy office
Those who instigation of lawsuits, typically groundless ones
Hypocrites
Thieves
Counselors of fraud
Sowers of discord
Falsifiers
Lake Cocytus:
Traitors to their kindred, country, guests and lords

The page following shows slices from Botticelli's work with enlarged details of the boatman, the topic of Chapter 33, Twenty-Five Centuries of Subterranean Portraits.

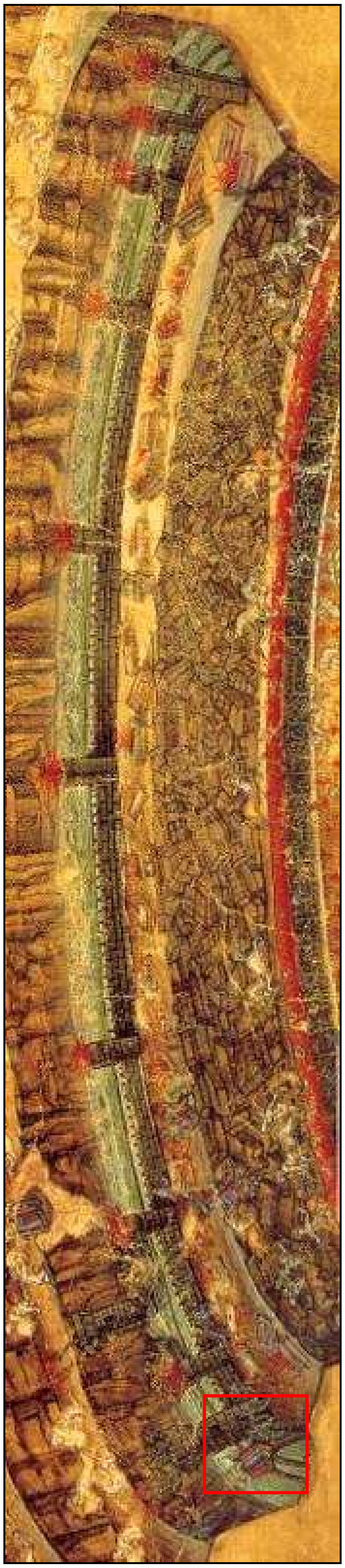


The River Acheron.

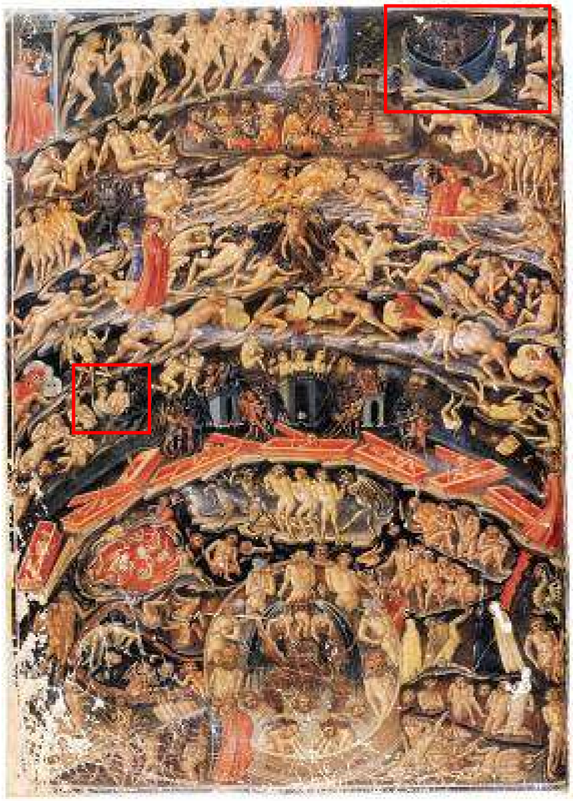


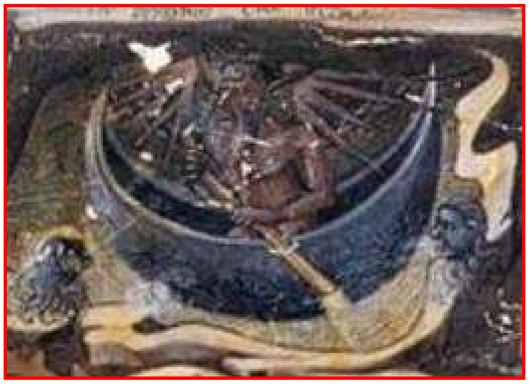


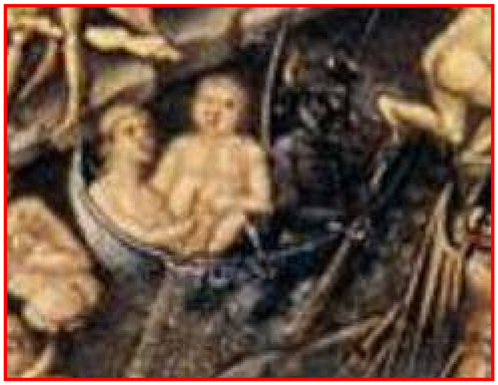
The River Styx.

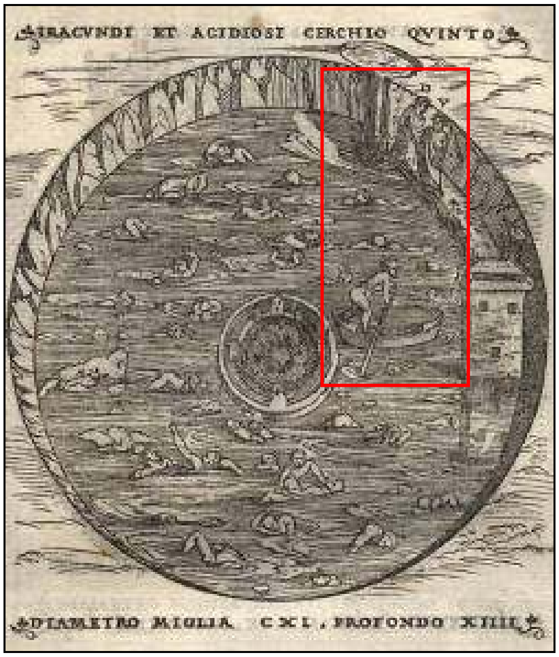


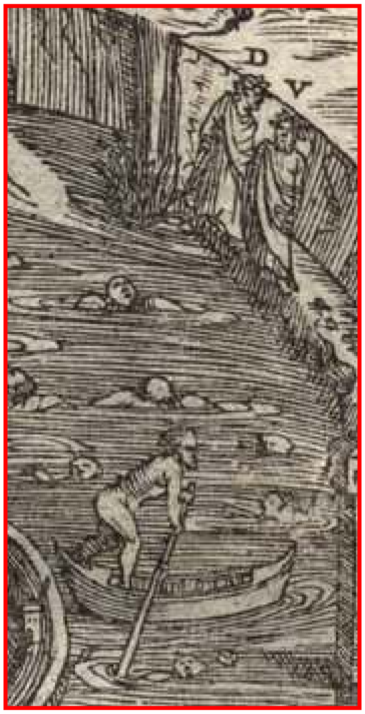
Below is Bartolomeo di Fruosino's tempera, gold, and silver on parchment (c. 1430). The gates of Hell are in the center, the scarlet row of open sarcophagi before them. Devils orchestrate the movements of the wretched souls.





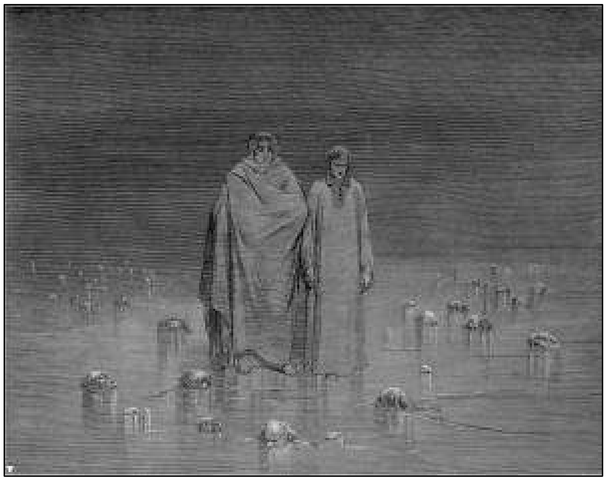



IRACVNDI ET ACIDIOSI CERCHIO QVINTO
DIAMETRO MIGLIA CXL. PROFONDO XIIII

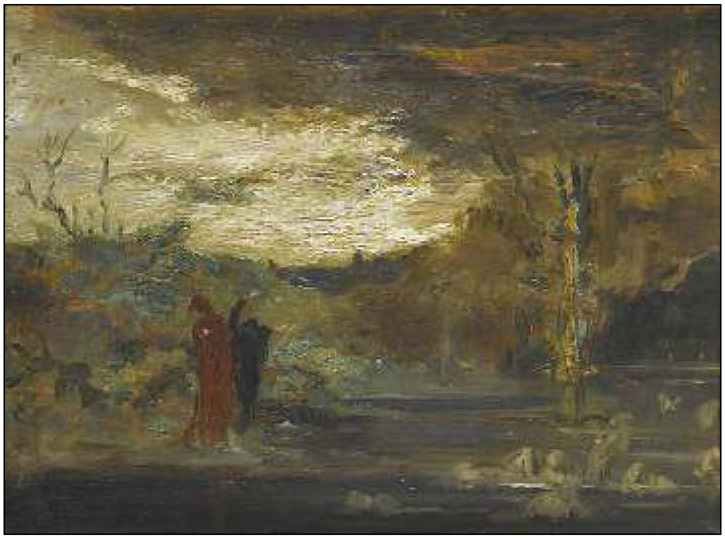


"D" and "V" in the 1544 woodcut are Dante and Virgil.

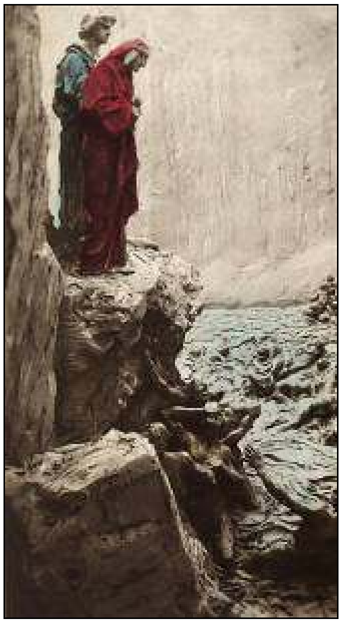
The Inferno's Cocytus is not a river, but rather a lake, and a frozen one at that. We'll discuss ice caves in Chapter 41, Underground Rivers in Caverns other than Karst, but compared to Gustave Doré's 1890 engraving (right), photographic illustrations aren't as gripping.



Below are works from the 19th and 20th centuries depicting the travelers overlooking the waters.



Gustave Moreau



Domenico Mastroianni

Are Dante's rivers underground?

Botticelli's is the standard physiographic interpretation of the Inferno's landscape, a funnel-shaped pit. The Illustrations of Chapter 33 generally portray sky -- not rock -- arching the scenes, but that may be because painters are known to prefer light. "Dentro dal monte" is Dante's nod to classical underpinnings, but his Acheron, Styx, Phlegethon and Cocytus aren't particularly subterranean.

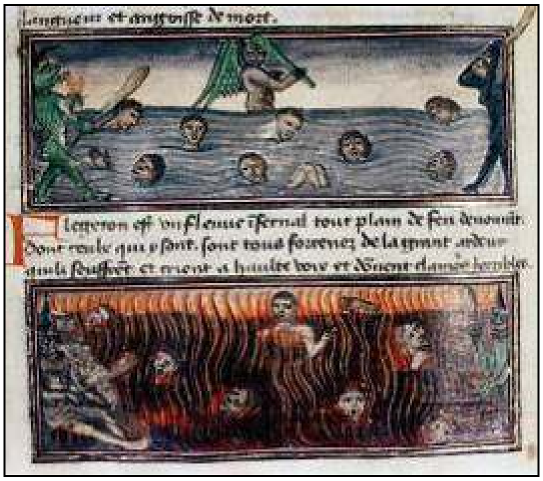
Are Dante's rivers even rivers?

From the first English translation, Charles Rogers (1782),

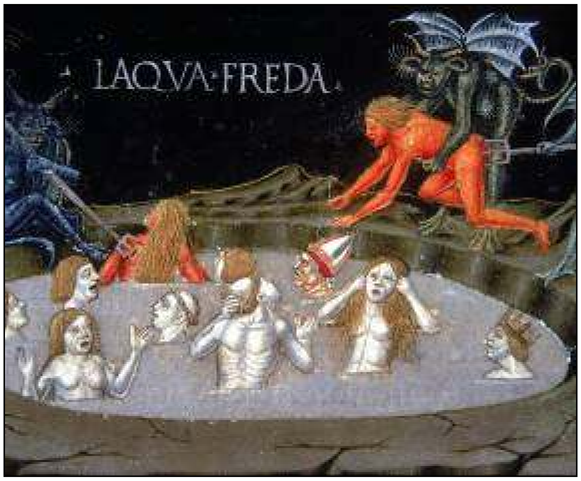
> *In la palude va c'ha nome Stige*
> A marsh it makes known by name of Styx

"Palude" can likewise mean bog, swamp or morass, but doesn't connote flowing water. Dante's Styx is a more-significant deviation from ancient lore than simply its undergroundedness, to coin a term. The writer bows to the dictates of Rome where a Charon wouldn't have authority to shepherd the repentant for appropriate remuneration, a job for which holy orders are qualification.

Dante's Styx isn't a boundary, but a quagmire of torment, a circle of Hell itself. The rivers are pools of perpetual punishment.



Styx and Phlegethon from Treatise on Anti-Christ, Judgment, Heaven and Hell(c. 1450-1470).

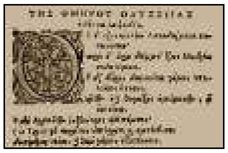


"The Torments of Hell," Codex of Christoro de Predis (c. 1486)

Should we thus disqualify the Inferno's Styx as but a sorrowful swamp, not a subterranean river?

No, we shouldn't. Reinterpretation is not redefinition. Subterranean rivers they originally were, and subterranean rivers they will always be.

In the manner of earlier chapters, following are correspondences to Homer's saga.

	 Odyssey (c. 855 BC)	 The Divine Comedy (1314)
Author	Homer	Dante
Protagonist	Odysseus	Dante
Setting	Mythical Mediterranean, Mythical times	Inferno, Purgatorio and Paradiso, 1300
Opening	*Tell me, O muse, of that ingenious hero who travelled far and wide after he had sacked the famous town of Troy.*	*Midway upon the journey of our life I found myself within a forest dark, For the straightforward pathway had been lost.*
Characters	Lotus Eaters	
	Cyclops	
	Sirens	*Hearing the Sirens, thou mayst be stronger.*
Rivers	Acheron	Ferried across
	Cocytus	Lowest circle of Hell, a lake frozen by the flapping wings of Lucifer
	Styx	Surrounding the lower part of Hell
	Pyriphlegethon	Phlegethon

Summary

So let us summarize what transpired in this and the previous two chapters, three segments of time, each in the range of 500 years.

The early Church assumed a neo-Platonic bent, elevating spiritual understanding above insight mired in worldly observation. To whatever minor degree the corrupted world merits consideration, so would hydrology, but the theology demands our attention.

The Arabs preserved a more-phenomenological Aristotelian world view and within that context, the lore of underground rivers expressed of Greek and Latin writings.

Intellectual vitality, both Arabic and European, came with the recognition of Greek legacy, a spectrum extending from the highest order of cosmology to the deepest channels within the earth.

Resurgent Christendom emerged more Aristotelian, more empirical. Underground rivers with mythical underpinning were again instruments of Christian instruction, albeit within the era's Christian bounds. Ecclesiastes 1:7 remained the pulpit theory of subterranean streams, but an awakened intellectualism was beginning to seek a broader understanding of the workings of God's world.

CHAPTER 7

THE CONCEPT OF CIRCULATION

This chapter, The Copncept of Circulation, and the two following, Subterranean Mechanisms and Superterranean Metrics, together trace the formation of hydrology as a physically-based science, and thus a means to assess the flow of water underground.

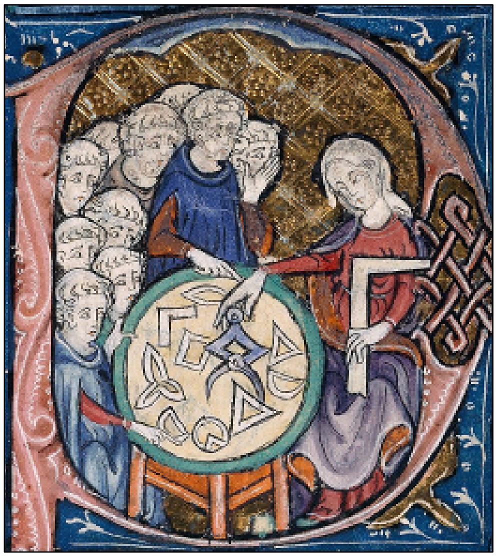
We could sequentially march through several centuries of scientific history, noting who solved what challenge at what time. To continue our journey a bit more thematically, however, we'll do it in three passes.

In this chapter we will follow the concept of circulation through the Renaissance and into the formative age of science. We will note the problem of rainfall perceived to be less than streamflow and how a vast subterranean abyss might serve as a logical solution. We will see how a dual hydrologic cycle seemed to bring everything together.

In the next chapter, Subterranean Engines, we'll concentrate on how subterranean resupply might work. Perhaps seawater is squeezed upward by the earth's weight. Perhaps it's by electricity. We'll see some innovative causality when data's not of concern.

And in the following chapter, Superterranean Metrics, we'll note what was realized once observers began to measure the observables. We'll see rudimentary numbers, but once there was data, subterranean sea-to-spring piping began to seem less necessary.

We should pause, however, to recall the roots of this chapter in what was fairly well extablished in by late-medeival Christian interpretation.



Adelard of Bath (1080-c. 1152) contributed the first full Arabic-to-Latin translation of Euclid's Elements, a work not printed however, until the 14th century. To the right, the frontispiece shows a woman -- Sophia, we might imagine --teaching geometry to monks.

Adelard's Quaestiones Naturales, written as a dialogue between the author and his nephew, includes questions regarding rivers.

> *For neither do all rivers flow down into the sea, nor do none of them. But as some flow down into it, so also others are born from it. Thus if, while it receives, it gives back, a perceptible increase in its volume does not occur. In fact, since many underground rivers arise from the sea, and the quaffing of the planets takes away a large part of the water, some people have been puzzled about how the sea does not suffer a loss, and how it receives sufficient water in compensation.*

> *In a circular process there is neither a beginning nor an end. For anything to which this can apply can be returned into itself. Rivers which flow perpetually, in case you are unaware, have naturally acquired a circular movement. They therefore return into themselves, and what has flowed away in their going, they give back by returning. Hence the Satirist, in making fun of the stupidity of the common people, says:*

> *"The country bumpkin waits for the river to flow away, but it flows and will flow, rolling on for ever."*
>
> *Since the rivers divide into many different courses in the bowels of the earth, it can happen that they sometimes meet a terrain which is obstructed on all sides by rocky outcrops and forces them to flow upwards, if the only exit is in that direction. So when they are always ascending, they always flow out.*

Cardinal Bonaventure of Bagnoregio (1221-1274) preached on the Holy Spirit's gift of grace.

> *Upon this Ecclesiastes: "To the place, whence the rivers go forth, they return."* [St. Bernard] *says, that "the origin of springs is the sea, the origin of virtues and sciences is Christ."*
>
> *For as the spring does not have length, unless it has a continuous conjunction with its origin, so also light; thus the grace of the Holy Spirit cannot grow in the soul unless through its reversion to is own original Principle.*

The Cardinal likewise is speaking of circulation.

The Renaissance

The term "circulation" derives from the Greek "kirkos" for circle. In generalized mythology, the circle said to be,

> *A symbol of the Self. It expresses the totality of the psyche in all its aspects, including the relationship between man and the whole of nature. It always points to the single most vital aspect of life, its ultimate wholeness.* -- Marie-Louise von Franz in Carl Jung's Man and His Symbols (1979)

To Jungian psychologists, through "decensus" and "ascensus" we find meaning.

We routinely envision the Renaissance -- "rebirth" in Italian, the cultural movement spanning the 14th to 17th centuries -- in terms of art, but our journey is about intellectual forays, in particular about waters flowing beneath the earth. We'll look at the Renaissance in terms of how it applied the circle to that question.

As Marjorie Nicolson observes,

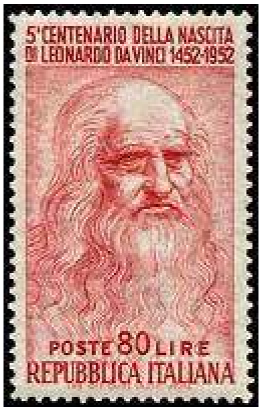
> *No metaphor was more loved by Renaissance poets than that of the circle, which they had inherited from Pythagorean and Platonic ancestors, who in turn had borrowed it from Orientals, to whom the serpent, swallowing its tail, was a Hieroglyphick of eternity.* The Breaking of the Circle (1962)

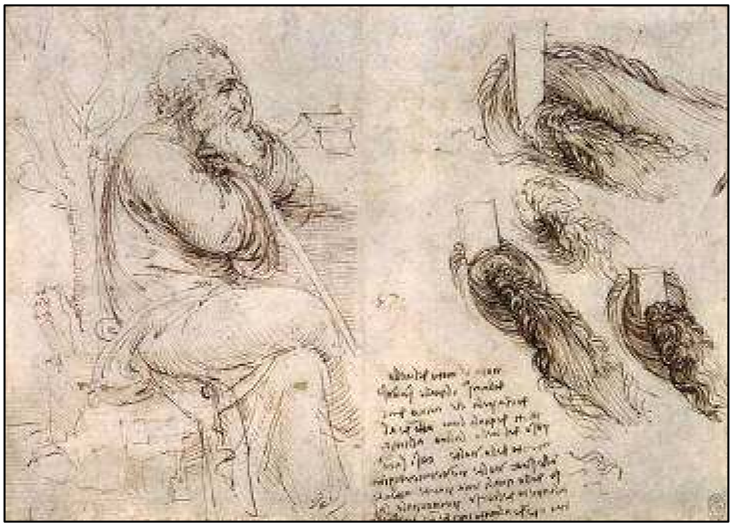
Core to the Renaissance was the rediscovered Greco-Roman culture. By cleaning and sharpening the tools of antiquity, observers could refocus their own eyes. We must keep in mind, however, that no eye, then or now, can peer below the earth. The patterns mapped our consciousness may be significantly unlike what a drilling rig might puncture. The problem of perception isn't, of course, confined to issues of proper illumination. Science is a story of peering through the muddle of sensibilities.

Turning from the clerics' abstract speculation about the afterlife, the Renaissance was marked by interest in the visible, in tactile knowledge. Freed inquiry was more important to the future of thought than immediate specification.

The Florentine polymath Leonardo da Vinci (1452-1519) merits centerpiece status in our underground sojourn if for no other reason than his encyclopedic curiosity. Da Vinci's "primo motore" lies squarely within the Christian god's perceived role for the era. Da Vinci's doctrinal dues thus paid, he was somewhat of a pantheist, largely excluding the divine from his musings. Aristotle would have concurred.

LEONARD DE VINCI
1452
1519
30f


5° CENTENARIO DELLA NASCITA DI LEONARDO DA VINCI 1452-1952
POSTE 80 LIRE
REPUBBLICA ITALIANA



The circa 1513 sketch shows the elder artist pondering the flow of water. The backwards-inscribed text reads,

> *Observe the motion of the surface of the water, how it resembles that of hair, which has two motions -- one depends on the weight of the hair, the other on the direction of the curls; thus the water forms whirling eddies, one part following the impetus of the chief current, and the other following the incidental motion and return flow.*

Despite da Vinci's oft-cited, "In talking about water, remember to call upon experiment and then on reasoning," rarely, if ever, did he subject his concepts to physical test, again falling in with Aristotle. Da Vinci honored the here-and-now, but not to the point of getting his hands wet.

But da Vinci's experimental shortcoming didn't inhibit his greatest strength. "Do you not see that the eye embraces the beauty of the whole world?" The visual is pre-eminently the real. What da Vinci saw he never doubted -- Aristotelian to the fullest.

To da Vinci, water is "il vetturale di natura," the vehicle of nature. In his First Book on Water (one of his few manuscripts written thematically, not as happenstance observations), da Vinci writes.

> *Water is sometimes sharp and sometimes strong,*
> *sometimes acid and sometimes bitter,*
> *sometimes sweet and sometimes thick or thin,*
> *sometimes seen bringing hurt or pestilence,*
> *sometimes health-giving and sometimes poisonous.*
> *It suffers change into as many natures as are the different places through which it passes.*

Unfortunately for focused scholarship, da Vinci's "many places" was indeed many.

> *If you chose to say that the rains of the winter or the melting of the snows in summer were the cause of the birth of rivers, I could mention the rivers which originate in the torrid countries of Africa, where it never rains -- and still less snows -- because the intense heat always melts into air all the clouds which are borne thither by the winds.*

> *And if you chose to say that such rivers, as increase in July and August, come from the snows which melt in May and June from the sun's approach to the snows on the mountains of Scythia and that such meltings come down into certain valleys and form lakes, into which they enter by springs and subterranean caves to issue forth again at the sources of the Nile, this is false; because Scythia is lower than the sources of the Nile, and, besides, Scythia* [Asia as far as India.] *is only 400 miles from the Black Sea and the sources of the Nile are 3000 miles distant from the sea of Egypt into which its waters flow.*

From da Vinci's writings concerning subterranean waters,

> *Very large rivers flow under ground.*
>
> *The body of the earth, like the bodies of animals, is intersected with ramifications of waters which are all in connection and are constituted to give nutriment and life to the earth and to its creatures. These come from the depth of the sea and, after many revolutions, have to return to it by the rivers created by the bursting of these springs.*

In the chapter to follow we will discuss da Vinci's comments regarding mechanisms of underground rivers, but for now let us simply note that never was he scientifically correct, and when his understanding drew close to what we now know, elsewhere he'd argue to the opposite.

Da Vinci's contradictions are understandable in a world where science had yet to be invented. Why not have multiple reasons for the same behavior? Though da Vinci's subterranean rivers existed no more in reality than did those of Aristotle, the latter's claims were little but rehashed mythology. Da Vinci's waters were phenomenological propositions with nary a courteous nod to Charon.

Concerning the hydrologic cycle, da Vinci employed the circular metaphor of his day.

> *Thus the movement of the water inside and outside varies in turn, now it is compelled to rise, then it descends in natural freedom. Thus joined together it goes round and round in continuous rotation, hither and thither from above and from below, it never rests in quiet, not from its course, but from its nature.*

And,

> *That which to the utmost admiration of those who contemplate it raises itself from the lowest depth of the sea to the highest summits of the mountains and pouring through the broken veins returns to the deep sea and again rises with swiftness and descends again, and so in course of time the whole element circulates.*

Da Vinci turned to the Nile for proof.

> *And do you not believe that the Nile must have sent more water into the sea than at present exists of all the element of water? Undoubtedly, yes. And if all this water had fallen away from this body of the earth, this terrestrial machine would long since have been without water. Whence we may conclude that the water goes from the rivers to the sea, and from the sea to the rivers, thus constantly circulating and returning, and that all the sea and the rivers have passed through the mouth of the Nile an infinite number of times.*
>
> *Therefore it may be said that there are many rivers through which all the element has passed and have returned the sea to the sea many times.*

The Nile appears frequently in underground river lore. We saw it mapped in Chapter 2, Greek Philosophers. We'll note a pyramid update in Chapter 57, Cargo Conveyance. The Greeks pondered the mystery of Egypt and we do likewise today.

By the time of Columbus, there was no opposition to the proposition that the sun was the engine for the cloud-fed portion of the dual cycle. According to da Vinci,

> *Moreover the elements repel or attract each other, for one sees water expelling air from itself, and fire entering as heat under the bottom of a boiler and afterwards escaping in the bubbles on the surface of the boiling water. And again the flame draws to itself the air, and the heat of*

> *the sun draws up the water in the form of moist vapor, which afterwards falls down in thick heavy rain.*
>
> *And these are carried by the winds from one region to another, until at last their density gives them such weight that they fall in thick rain. But if the heat of the sun is added to the power of the element of fire, the clouds are drawn up higher and come to more intense cold, and there become frozen and so produce hail.*

And here, da Vinci is at his best.

> *The element of fire by its heat always draws to itself damp vapors and thick mists as opaque clouds which it raises from seas as well as lakes and rivers and damp valleys; and these being drawn by degrees as far as the cold region, the first portion stops, because heat and moisture cannot exist with cold and dryness; and where the first portion stops, the rest settle, and thus one portion after another being added, thick and dark clouds are formed.*
>
> *At times it is bathed in the hot element and dissolving into vapor becomes mingled with the air, and drawn upwards by the heat it rises until it reaches the cold region and is pressed closer together by its contrary nature, and the minute particles become attached together.*

We'll return to more of da Vinci's circle-driving inspirations in the chapter to follow, but before we begin to think mechanically, let us look ahead regarding a darker view of circulation.

Robert Hooke (1635-1703), whose name is applied to the law of elasticity, was the son of a minister who “died by suspending himself.” From Hooke's dismally-titled The Earth Grows Old and Less Fruitful (1705),

> *Nature... is, as it were, a continual circulation. Water is rais'd in Vapors into the Air by one Quality and precipated down in drops by another, the Rivers run into the Sea, and the Sea again supplies them. Generation creates and Death destroys. Winter reduces which Summer produces... All things almost circulate and have their Vicissitudes.*

It's a glum Ecclesiastes 1:7 which today we would call it the Second Law of Thermodynamics.

The Perception of Precipitation Insufficient to Sustain Streamflow

In beginning of this chapter, we noted a flawed perception, that precipitation is less than streamflow. No free-thinker standing on the banks of a mighty waterway on a drizzly Renaissance day thought other than, "Flumen est maioribus quam pluvia." The river flows more than the rain.

Were water not circulatory -- if water simply came into existence as needed -- the system would have little need for an underground conduit. And if nature didn't need the latter, there would be no need for a subterranean resource to supply the underground river.

But as the rivers flow full, there must be the unseen replenishment, and thus there must be the deeper source.

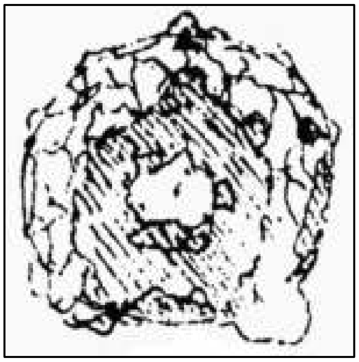
By 1500, Aristotle, not Plato, was the designated pre-Christian philosopher, but Plato's Tartarean abyss yet had reason to exist.

And once again we note that it's hard to keep a good story down.

The Abyss

The concept of a great void in the earth center goes back to Plato, but its Biblical basis -- depending on how the reader takes the Bible, of course -- propelled the concept into nearly-modern times.

To the right is a da Vinci cross-section of the distribution of land, mountains, oceans, lakes and rivers at the surface and a water ball in the interior.



In his words,

> *This is meant to represent the earth cut through in the middle, showing the depths of the sea and of the earth; the waters start from the bottom of the seas, and ramifying through the earth they rise to the summits of the mountains, flowing back by the rivers and returning to the sea.*
>
> *The great elevations of the peaks of the mountains above the sphere of the water may have resulted from this that a very large portion of the earth which was filled with water, that is to say the vast cavern inside the earth, may have fallen in a vast part of its vault towards the centre of the earth.*

"A vast cavern," to fire our imaginations! We'll see where the fiction writers take the topic in later chapters.

Arts des Fontaines et Science des Eaux (1665) by Jesuit Jean François (1582-1668) endorsed the presence of great subterranean caverns.

> *The earth's crust, dried out, ends by cracking. The water underneath expands and exerts pressure against the vault of the orb, which will break into pieces and fall into the abyss. The cracked crust, weakened, breaks up; water gushes violently out, in proportion to its mass and the space it had just occupied.*

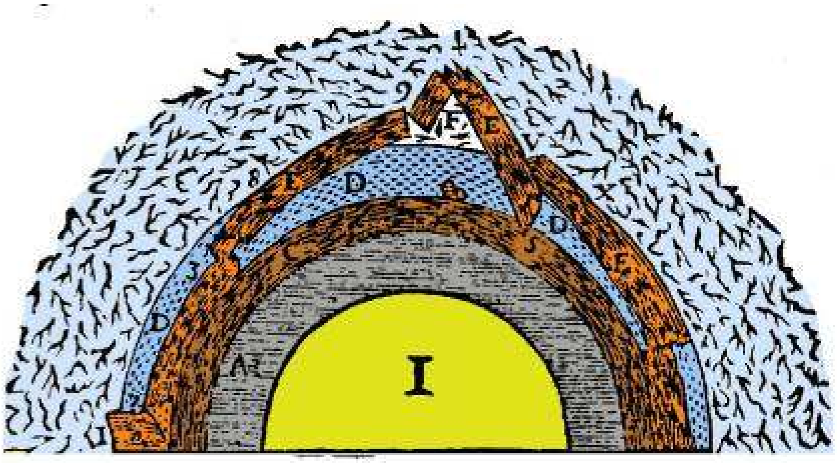
Jean François' student, René Descartes (1596-1650) soldiered and traveled before embracing solitude to pursue his treatises. His proof of the equivalence of Euclidian geometry and the algebraic geometry still stands. His principle of the constancy of universal "momentum," on the other hand, died with the publication of Newton's Principia in 1687.

RÉPUBLIQUE FRANÇAISE
DISCOURS SUR LA MÉTHODE 1637
DESCARTES
90c
H. CHEFFER

As we might expect, the author of "Cogito, ergo sum" would apply the power of reason to the problem at hand. According to Descartes, the sun-like core of the earth was originally surrounded by a shell of metals which in turn was enclosed by progressive spheres of water, earth and air. As the inevitable decay of earthly materials began, portions of the shell cracked and collapsed into the water below, the rocky protrusions becoming the modern continents and the sunken earth, the sea floor.

The figure below illustrates the process.

> *But there being many crevices in the body E, which enlarge more and more, they are finally become so great that it cannot be longer sustained by the binding of its parts, and that the vault which it forms bursting all at once, its heaviness has made it fall in great pieces on the surface of the body C. But because this surface was not wide enough to receive all the pieces of this body in the same position as they were before, some fall on their sides and recline, the one upon the other.* -- Discours de la Méthode (1637)



> *As a result, we may think of the bodies B and F as nothing other than air, that D is the water and C, a very solid and very heavy crust upon the earth's interior, from which come all the metals, and finally that E is another, less massive, crust of the earth, composed of stones, clay, sand, and mud.*

Note the resultant sites of D, the water, some upon the surface, other beneath the earth. Plato's abyss has found a degree of quasi-scientific sense.

From Principles of Philosophy (1644),

> *There are great cavities filled with water under the mountains where the heat of the sun continually raises vapors which, being nothing more than fine particles of water strongly shaken one from another, escape through pores in the earth and go to higher plains and mountains, regroup themselves in the interior of fissures near the surface which when filled, cut through the soil and form springs which run to the lower valleys, and converge into rivers which flow to the sea. Now in spite of this process, much water continuously flowing from these cavities under the mountains never empties them; this is due to the existence of numerous conduits by which seawater flows to these caverns in the same proportion as that which exits to the springs.*

A macabre historical note: After his natural death, Descartes' head was detached from his body and it was recorded that the anterior and superior regions of his skull were rather small, leading German phrenologist Johann Gaspar Spurzheim (1776-1832) to suggest that Descartes could not have been as great a thinker as previously believed.

As a variation more in keeping with Biblical chronology, Englishman John Woodward (1665-1722) explained that the earth was a watery spheroid with a solid crust that broke apart and dissolved in Noachian food to re-sediment into the topography we now know.

> *There is a mighty collection of Water inclosed in the Bowels of the Earth, constituting a huge Orb in the interior or central Parts of it; upon the Surface of which Orb or Water the terrestrial Strata are expanded. This is the same which Moses calls the Great Deep or Abyss; the ancient Gentile Writer, Erebus, and Tartarus. --* An Essay toward a Natural History of the Earth and Terrestrial Bodies, Especially Minerals, as also of the Sea, Rivers and Springs. With an Account of the Universal Deluge and of the Effects that it had upon the Earth (1695)

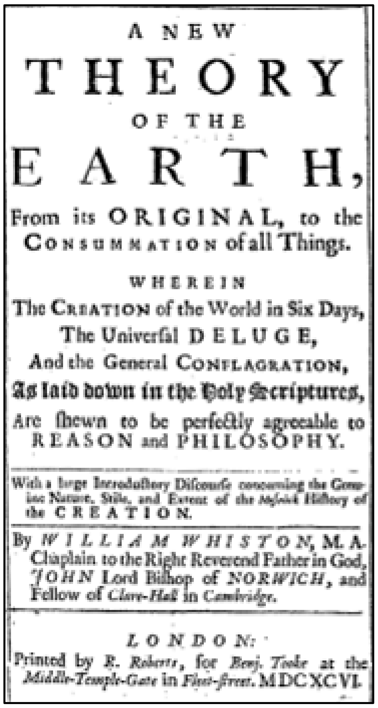
Other 17th-century works such Georges Fournier's Hydrographie Contenant la Thiorie et la Pratique de Toutes les Parties de la Navigation (1667) gave similar accounts of rivers and reservoirs within earth's interior.

William Whiston (1667-1752) was the best-known British author dealing with the genesis of the earth. Succeeding Newton as Professor of Mathematics in Cambridge, Whiston edited and published Euclid's geometry and wrote textbooks on astronomy and physics.

Availing himself of Newtonian ideas, Whiston's A New Theory of the Earth, from its Original, to the Consummation of All Things (1696) explained geological catastrophe, not by human sin, but by a water-tailed comet which on November 28, 2349 BC which distored the crust, making "Gaps and Clefts ... quite through it" and opened "the fountains of the great deep."

The waters eventually receded due to two causes:

> *First by a Wind which dried up some and secondly, by their descent through those Fissures, Chaps and Breaches, (at which part of them had before ascended) into the Bowels of the Earth, which received the rest. To which later also the Wind, by hurrying the Waters up and down, and so promoting their lighting into the before-mention'd Fissures, was very much subservient.*



A NEW
THEORY
OF THE
EARTH,
From its ORIGINAL, to the
CONSUMMATION of all Things.
WHEREIN
The CREATION of the World in Six Days,
The Univerſal DELUGE,
And the General CONFLAGRATION,
As laid down in the Holy Scriptures,
Are ſhewn to be perfectly agreeable to
REASON and PHILOSOPHY.

With a large Introductory Diſcourſe concerning the Genuine Nature, Stile, and Extent of the Moſaick Hiſtory of the CREATION.

By *WILLIAM WHISTON*, M.A.
Chaplain to the Right Reverend Father in God,
JOHN Lord Biſhop of *NORWICH*, and
Fellow of *Clare-Hall* in *Cambridge*.

LONDON:
Printed by *R. Roberts*, for *Benj. Tooke* at the
Middle-Temple-Gate in *Fleet-ſtreet*. MDCXCVI.

Benjamin Franklin (1706-1790) was of similar opinion regarding a primordial crust floating on a fluid interior.

> *Thus the surface of the globe would be capable of being broken and disordered by the violent movements of the fluids on which it rested.*

Ukrainian Johannes Herbinius' (1633-1676) Dissertationes de Admirandis Mundi Cataractis et Subterranis (1678) supported the abyss concept, but hedged regarding causality. The reason for continuous flow through the "great central abyss" may be God, angels, stars, the spirit of the earth or perhaps the air within. Herbinius held that ocean water circulates continuously from the North to the South Pole via the center of the earth and attributed tides to the periodic ejection of water from reservoirs beneath the poles. An engraving shows a "Hydrophylacium Subterraneum" but the text gives no indication of magnitude.

Concerned with public health, Bernardino Ramazzini (1633-1714) accounted for the "wonderful springs of Modena" in De Fontium Mutinensium (1691).

> *Seeing the Nature and Origin of this hidden Source deserves to be as much enquired into as that of the Nile did formerly, let us pass through these Subterraneous Waters with the sails of our Reason.*
>
> *And I think 'tis probable the matter is so in our Fountains, to wit, the Water flows out of some Cistern plac'd in the neighboring Mountains, by subterraneous Passage.*
>
> *But 'tis, by far, more probable, that the Water is sent from the sea into such Claim, than from Showers, or melted Snows, seeing Rain and Snow-waters run away for the most part by Rivers above Ground; neither can they enter into the ground so deep; as Seneca also testifies.*

Regarding the origin of waters,

> *As I have deduced from the Origin of this Water from the Sea, so I do not deny, that many Fountains owe their Origins to Rains and melted Snow; yet with this difference, that the Fountain which have their Spring from the Sea by hidden Passages continue perpetual, but those which run from Showers and temporary Springs at some time of the year, are diminished and quite dry up.*

> *I thought beat therefore to fetch the Origin of these Waters from another source, viz. From some secret Cistern of Water placed in the inner parts of the Apennine Mountains. And it is certain, that the inner parts of the Mountains are cavernous, and that there are in them Cisterns of Water, from whence Fountains and Rivers drawn their Origin.*
>
> *The arms for the springs are two arms, their motto: "Avia, Pervia," the path of the wanderers.*

By 1700, geology had evolved into an emerging objective science in which physical observation demanded logical, mechanistic and consistent explanation. Whereas Biblical accounts could never -- according to long-held theology, that is -- be false, God's execution of that truth was via the forces of nature. And in what power of nature might better explain the remnants of prehistory -- fossils in the mountains, being an example -- than God's direction of water?

Thus the 18th and 19th-century geological theory of Diluvialism, the intellectual attempt to reconcile the geological record by reference to Noah's Flood.

John Hutchinson (1674-1737) believed all terrestrial matter at creation was suspended in a hollow spherical mass of water, in the middle of which was a central mass of air. The solid matter then separated from the water to form a crust over the central air and beneath the water. When light was ordained, the internal air expanded and burst out, being replaced by the water.

The Flood itself was caused by an increase in atmospheric pressure, produced by God, which forced air back into the Abyss, displacing the water. According to The Philosophical and Theological Works of John Hutchinson (1749), the water then drained partly through holes in the bottom of the sea and partly via "Fissures, Swallows, and Cracks in the Strata," eroding them into caves. He believed similarly that the water of springs and rivers comes from the Abyss, rising through the fissures that had been made by retreating water of the Flood.

Hutchinson's disciple Alexander Catcott noted that the water in Wookey Cave (Chapter 51, The Tourist Trade Worldwide) "may in some measure indicate the free communication there must be with the waters in the Abyss in this place."

Catcott's work appeared in A Treatise on the Deluge; containing ... Natural Proofs of the Deluge, Deduced from a Great Variety of Circumstances, on and in the Terraqueous Globe, and ... the Cause of Caverns or Natural Grottos; with a Description of the Most Remarkable, Especially those in England (1761).

> *From the consideration of things upon the surface of the earth, let us now descend into the inside, and see what proofs we can aduce from thence of an Universal Flood. And here let us enter the subterranean Kingdom by those easy and convenient passages, -- the natural Caves and Holes in the Earth: and in the first place collect what evidence we can for the point in question from the Caves themselves.*
>
> *Proof that these caverns were formed by water, or, that rapid currents of that fluid have passed through them, may be drawn from the multitude of in-land pebbles that are to be found in most of them ... they are not only to be found at the bottoms or in the lower parts of these Caves, but even high up in the niches and covered cavities in the sides, and many of these pebbles consist of a different kind of stone from that of the rock of the cavern, so that they must have come from far, and the streams that brought them been rapid and strong.*

The cave-forming action of the violent drainage surged to and fro, thus having repeated effect.

> [The water] *returned from off the earth continually ... in going and returning; inflowing backwards and forwards, in fluctuating here and there; for as the Airs began to ascend before the Waters began to descend, they would of course impede and in part drive back the waters and so cause afluctuating or reverberating motion in them*

The "airs" which occupied the Abyss while the water flooded over the earth would have interfered with the draining down in the manner that water emptied from a flask is interrupted by air bubbles rising against its flow.

Streams today in caves could not possibly have been responsible for their formation.

> *And lest anyone should imagine... that ... swallets in general might have been formed by river water, let it be remembered that they are commonly found upon the tops of the highest mountains, especially such as have extensive flats, where neither river nor rain-water could have any force to tear such Cavities, and therefore they could not owe their origin to such a Cause.*
>
> [Fissures connecting with the Abyss] *serve as canals for the Water which supplies Springs and Rivers to run in.*

Alexander's brother Georgeheld a similar opinion.

> *In the Roof of these Caverns, and upper Parts of the Sides, are a great Number of Cavities in the solid Rock, in Form of inverted Funnels, which as they widen in Proportion to their Depth, prove they could not have been made by Art* [i.e. mining}, *(as some have absurdly asserted) but by the Retreat of the Waters which flow thro' them, into the great Abyss beneath, at the Time of the universal Deluge.--* A Descriptive Account of a Descent Made into Penpark-Hole (1772, 1775).

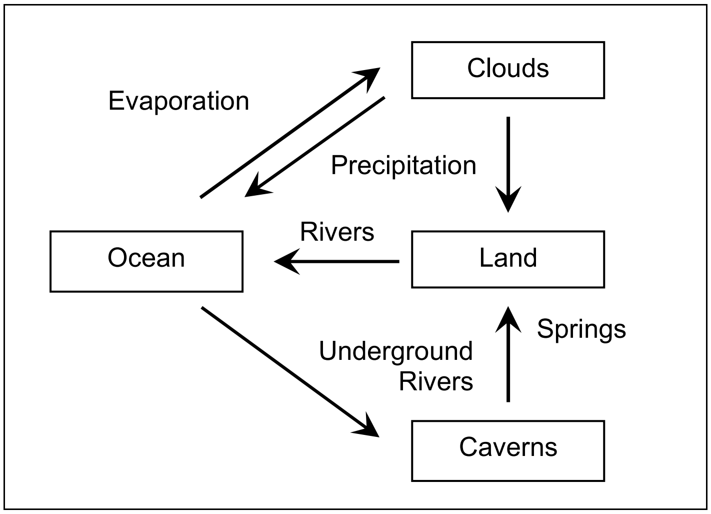
By the 18th century, however, fewer and fewer scholars saw reason piece together God's doings in that week of creation. The task at hand was that of finding a model that explained modern nature.

There was need to reconcile three perceptions regarding rivers.

> The circle as an unbroken expression of God's holiness,
> An Aristotelian impressions that streamflow exceeds rainfall, and
> The Platonic belief in subterranean reservoirs and channels.

The Dual Hydrologic Cycle

As put by Ramazzini, "The arms for the springs are two arms," the hypothesis of the dual hydrologic cycle.



The Dual Hydrologic Cycle

The upper loop, that which can be observed upon or above the earth's surface, agrees with modern pluvial theory, though today we'd include factors such as a box representing vegetation.

The lower loop, that which is within the earth, disagrees with modern evidence, but we not hold it against those working in an era before evidence was considered. We'll bring the diagram up to date in Chapter 38, Hydrogeology.

A dual cycle made sense in a time when water was thought to have opposing effects: water from above eroding of the continents and water from below rejuvenating the mountaintop.

The Tuscan Ristoro d'Arezzo (1223-1283) proposed in his treatise La Composizione del Mondo (1282) that the central cause of mountains resides with the stars. The heavens have a mountain and valley character, and where there is a mountain in the heavens, there is a corresponding valley on the earth. (We will see something similar when we consider the "contrapositionality" of hollow earth hydrocartography, Chapter 26.) The “virtues of the heavens” call water to rise as a magnet attracts iron.

Da Vinci drew upon La Composizione del Mondo, explaining how water washes gravel down-slope to raise valley elevations while subterranean streams bear earth upward on a seasonal basis.

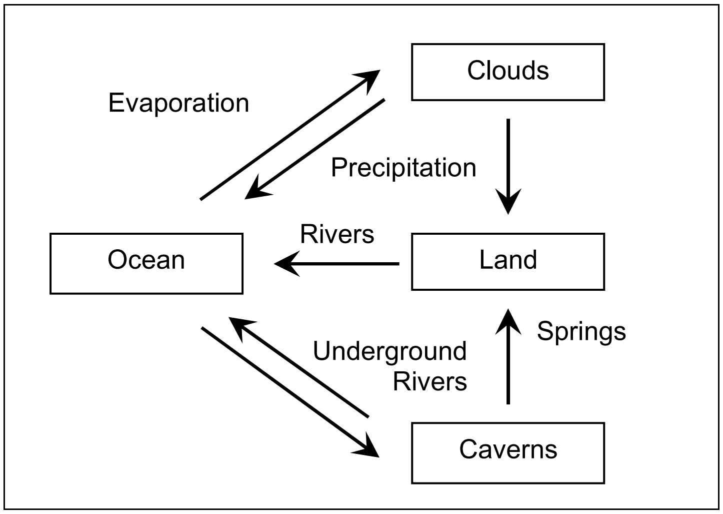
Bernard Varenius, author of Geographia Generalis (1692), the day's standard reference on physical geography, saw the cycle as dualistic.

> *Therefore the waters of Fountains proceed partly from the Sea or Subterranean waters, partly from Rivers, and Dew, that moisten the Earth. But the water of Rivers partly proceedeth from Springs, and partly from Rain and Snow.*

A dual cycle could even explain closed basins, watersheds such as that of the Dead Sea having no visible outlet to the sea. From Jean Henri Hassenfratz' Les Presses de l’Ecole des Mines (1806)

> *Africa and Asia are in the shape of a cone dug out at the summit. The waters flow out in part into the center; they are reunited into the great lakes or interior seas from which they are transported to the sea, either by evaporation, or by underground conduits.*

To let the sumps of Africa and Asia drain to the abyss from where flow returns to the sea, we need only add an upward lower-left arrow to our schematic.

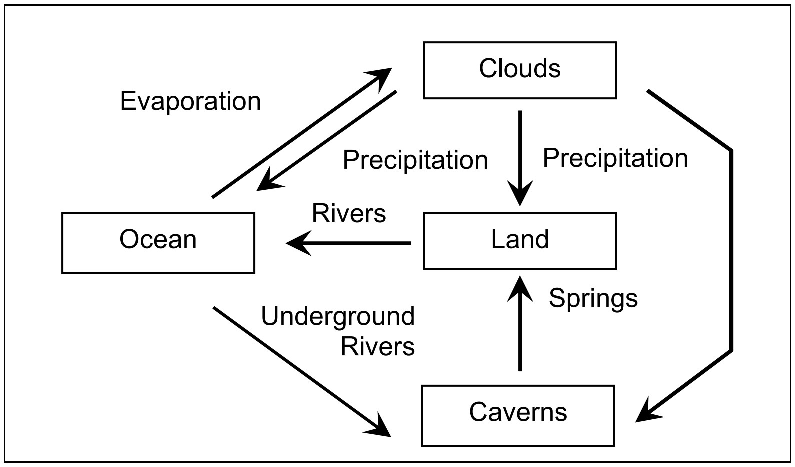


The Dual Hydrologic Cycle with Ocean Return

Isaac Vossius (1618-1689) was a Latin scholar who edited Pliny’s Naturalis Historia. Vossius' Aliorum Fluminum Origine (1666) allowed that caverns in fact might be directly fed by rainwater.

> *All Rivers proceed from a Colluvies of Rendezvous of Rain-water, and that, as the Water that falls upon the Hills, gathers more early together, than that which falls in Plaines, therefore it is that Rivers ordinarily take their Sources from Hills.*

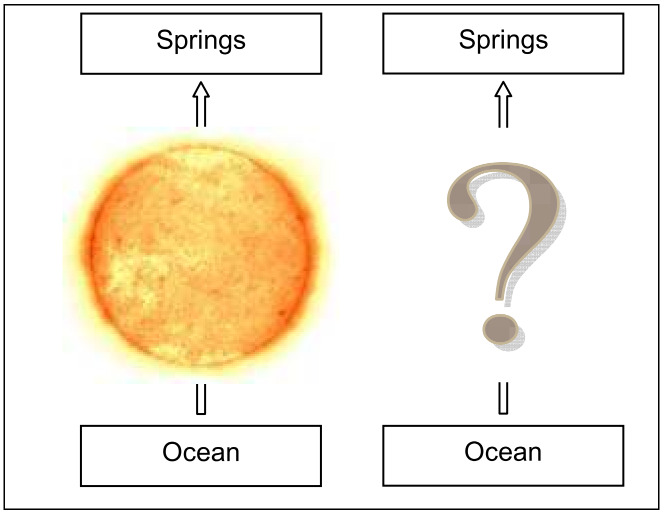
Our schematic needs but right-side arrow.


Clouds
Evaporation
Precipitation
Precipitation
Ocean
Rivers
Land
Springs
Underground Rivers
Caverns

The Dual Hydrologic Cycle with Rain-Fed Caverns

But we'll not advance our schematic beyond the thoughts of the times. The challenge isn't that of drawing arrows; it is that of explaining how the arrows work.

The diagrams below illustrate the dual mechanisms by which water returns from the sea to upland streams, Ecclesiastes 1:7 as schematic. The superterranean means was agreed upon by all -- it is the sun's power that draws water upwards. The motor on the left, the energy propelling subterranean streamflow -- for of course it's down there -- was yet unknown.


Springs
Springs
?
Ocean
Ocean

As we'll see in the chapter ahead, we've had lots of ideas about circulation. As Ramazzini would have phrased it, "Avia, Pervia!"

CHAPTER 8

TRANSMUTATIONAL AND BIOLOGICAL ENGINES

Having arrived on the shores of scientific inquiry, let us take stock of where we've traveled. The myth of underground rivers has been rooted in Western culture since the time of the Greeks. According to the Romans, there were many such rivers in distant lands. Reinterpreted in accordance with medieval theology, belief in such waterways acquired parochial authority.

But few pondered what powers such waters to the elevations of efflux? According to Aquinas, "streams... in the habit of doing this" are "something that everybody knows."

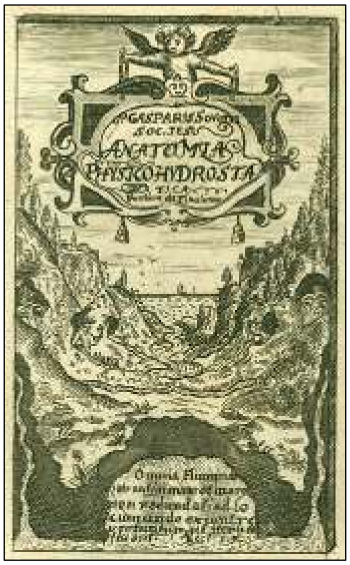
To Renaissance thinkers, however, the aesthetic of circular watercourses -- down the mountain slope and back up the interior -- begged for envisionable explanation.

It fell upon infant science, still laden with mythological legacy, but at last beginning to seek objectivity, to deduce the mechanism of rivers that were presumed to run underground.

Conceptual mechanization was by no means a straight-forward process, as noted as late as the 17th century by mathematician, physicist and magician Gaspar Schott (1608-1666). From his Anatomia Physico-Hydrostatica Fontium ac Fluminum Explicata (1663),

> *Sea water may be carried through subterranean canals to the surface of the earth and quite frequently to the top of the highest mountains. How this takes place in something which hitherto has baffled the minds of all and has led to an almost interminable amount of conjecturing.*

As to what might drive subterranean rivers upward, Schott has this to say in Athanasii Kircheri (1660), his commentary on a contemporary with whom we'll soon become better acquainted.



> *We are of the opinion that some springs and rivers have their origin from subterranean air and vapors which have been condensed into water. Others from rain and snow which has soaked into the earth, the greatest number and the most important rivers, however, from sea water rising through subterranean passages and issuing as springs which flow continuously. And so the sea is not the only source, at least it does not distribute its water through underground passages to all these springs and rivers.*
>
> *But this statement would seem to run contrary to the clear teaching of Holy Writ found in Ecclesiastes, chapter 1 and verse 7, All rivers run to the sea; yet the sea is not full; unto the place whence rivers cone, thither they return again.*

We're well acquainted with the Holy Writ, of course, from Chapter 6, but Schott, who was also a Jesuit, was in pursue of the "real meaning."

> *The real meaning of these words however seems to be: All rivers run into the sea, from the place out of which they come, to it they flow back again. Consequently these which enter the sea have issued from the sea, and those which have issued from the sea return to it and enter it that they may flow out of it again. But all enter it and all return to it, therefore all have issued from it. But it does not follow that some, as we believe, have not come out of the sea by another road than that just mentioned. I am, therefore firmly of the opinion and again repeat, all rivers do not issue from the sea -- at least all do not make their exit directly out of the ocean into*

> *the depths of the earth and from there rise through subterranean channels to their fountain heads.*

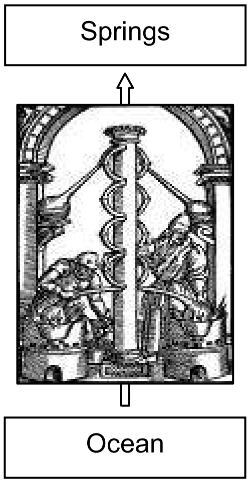
Schott evokes a grab-bag of underground flow mechanisms: up from the sea, except for that which derives from rain, snow or subterranean air. The era's "conjecturing" was indeed "almost interminable," but if we step back from the specifics, we find an engaged intellectual community sorting through the possibilities.

In this chapter we will sort through the first of many propositions easily dismissed in light of what's now text-book science, but mechanisms seemingly possible to intellectuals newly enamored with the concept of "mechanism." We'll consider a mechanism attractive to the Platonists, one of transmutation, and an alternative more attractive to the Aristotelians, a turn to biology.

In the two chapters to follow, we'll introduce explanations somewhat more mechanical, ones employing heat, force, electricity, topics today we classify as "physics." As Renaissance thinking didn't preclude wandering rationale, we will encounter da Vinci throughout.

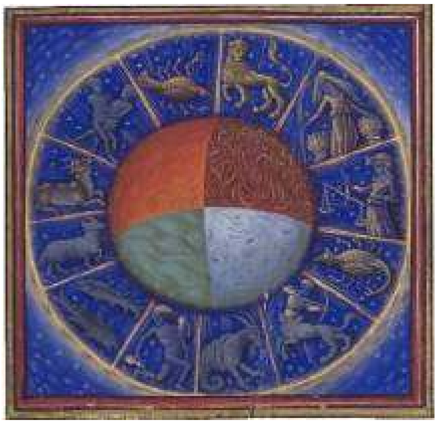
As noted in the introduction, the difference between science and superstition can be slight.

Transmutation



Perhaps ocean water becomes another element, rises through subterranean conduits to springheads and then reconverts to water. Pythagoras' speech in Ovid's Metamorphoses proclaims that although the elements have their natural seats, all likewise transmute.

> *Of these are made, to these again they fall.*
> *Received earth to water rarifies;*
> *To air extenuated waters rise;*
> *To air, when it itself again refines,*
> *To elemental fire extracted shines.*
> *They in like order back again repair;*
> *The grosser fire condenseth into air;*
> *Air into water; water, thickening, then*
> *Grows solid and converts to earth again.*
> *None holds his own: for nature ever joys*
> *In change and with new forms supplies.*



A 15th-century representation of the four elements: fire, air, water and earth

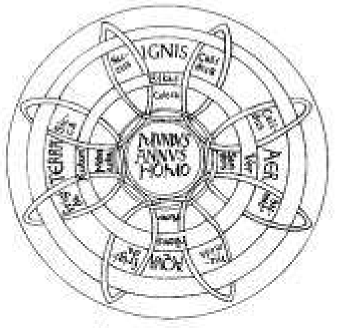
When burned, a substance -- wood, for example -- resolves into its elements. The fire is seen by its own light. Its smoke becomes air. From the ends of wood, water boils off. Ashes are the nature of earth.

Plato's elements were not distinct substances; they were principles. Fire was not the actual flame, but rather the principle of combustion. Water was the principle of fluidity; earth, the principle of solidarity. Air was that which filled vacant space.
Aristotle's universe was -- as we'd expect -- more physical. Finite and spherical, the globe was made of earth, air, fire and water proportioned 1:10:100:1000. Each element moves naturally in a straight line -- earth downward, fire upward -- toward its proper place determined by "heaviness." Terrestrial motion thus must come to a halt. The heavens, on the other hand, move endlessly in circular motion. The heavens are of a fifth element, either, a superior element incapable of change other than in circular movement.

Aristotle used the “primary qualities” of heat cold, moistness and dryness, to explain elemental natures,

hot + dry = fire
hot + wet = vapor
cold + dry = earth
cold + wet = water

As wetness cools, vapor becomes water. Because it is the nature of heat to rise, the heat in the vapor ascends to free itself. The cold in the vapor, having driven away the heat, presses itself closer together, restoring it to its natural liquid state.



Isidore of Seville’s De Responsione Mundi (1492) diagrams the primary qualities.

Neo-Platonist Christian mystic Gregory of Nyssa (332-396) pondered the question of Ecclesiastes 1:7. Why does the sea grow no larger? The answer: because God transmutes earth into water and water into earth.

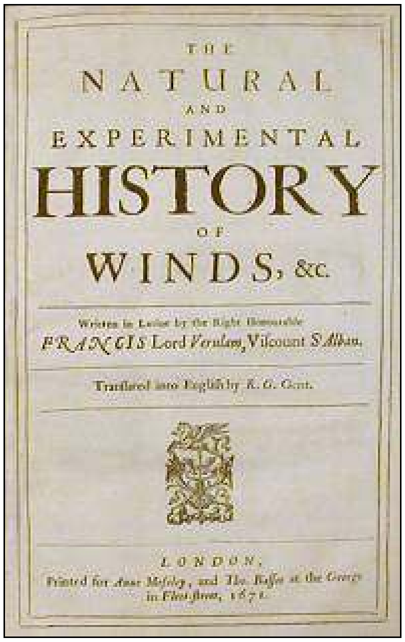
With the revival of Aristotelian sensibility (Chapter 6), however, transmutation by divine will was intellectually unsatisfactory. In Lecturae super Genesim (1385), Henry of Langenstein (1363-1382) proposed a three-fold explanation of springflow that was two-thirds correct. To wit,

> Springs issue from pores in the earth in which vapor has condensed or to which water has seeped from mountain places or has been drawn from within the earth.
>
> The pores also serve as entrance for surface waters returning to the sea.
>
> Some water in deep and obscure pores is influenced by the generative process of the earth and is transformed into metals and gemstones.

What is meant by "the generative process of the earth" isn't clear, but it's clearly transformation.

Da Vinci accepted elemental transmutation as fact, justifying the occurrence of water at high elevations as a product of elemental air. Wind is likewise explained where there was water.

> *The elements are changed one into another, and when the air is changed into water by the contact it has with its cold region this then attracts to itself with fury all the surrounding air which moves furiously to fill up the place vacated... But if the water is changed to air, then the air which first occupied the space into which the aforesaid increase flows must needs yield place in speed and impetus to the air which has been produced, and this is the wind.*



THE
NATURAL
AND
EXPERIMENTAL
HISTORY
OF
WINDS, &c.

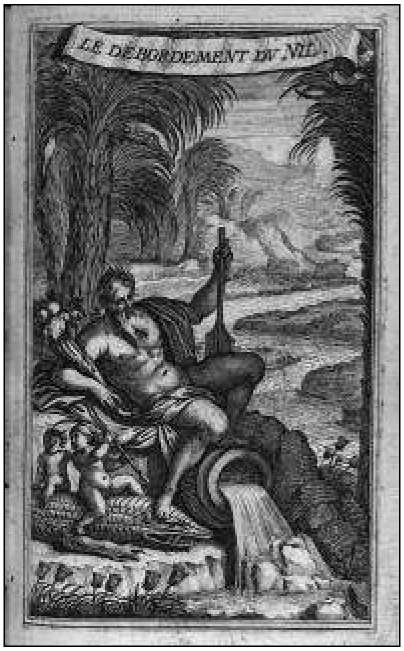
Written in Latine by the Right Honourable
FRANCIS Lord Verulam, Viscount S. Alban.

Translated into English by R. G. Gent.

LONDON,
Printed for Anne Mosley, and Tho. Basset at the George
in Fleet-street, 1671.

In Historia Ventorum (1622), Francis Bacon (1561-1626) wrote that air emitted from the earth's interior transformed itself into rain.

> *Winds do contract themselves into rain,... either being burthened by the burthen itself, when the vapors are copious, or by the contrary motions of winds, so they be calm and mild; or by the opposition of mountains and promontories which stop the violence of the winds, and by little and little turn themselves against themselves; or by extreme colds, whereby they are condensed and thickened.*



Pierre Cureau de la Chambre (1631-1693), on the other hand, made the distinction between constituent and state. From Discours sur les Causes du Desbordement du Nil (1666),

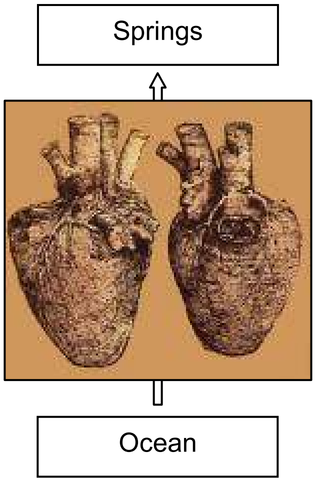
> *When nitre is heated by the heat of the sun, it ferments and mingling with the water, troubles it, swells it, and makes it pass beyond its banks; after the same manner as the spirits in new wine render it troubled and make it boil in vessel.*

The observation that the nitre (saltpeter) is mingled in the water -- as opposed to being derived from it -- signals the end of transmutation as hydrologic explanation, however. A quasi-chemical basis for flooding speaks to the times, if not the fact, but it at least doesn't involve created water.

As more-pragmatic science replaced Plato's natural philosophy, transmutational underground rivers fell from serious consideration.

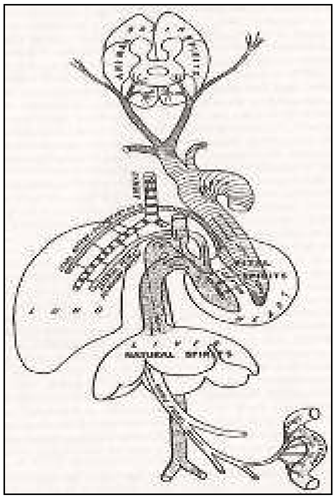
Much more attractive were models based on biology, ill-understood as it was, but in the mind of the Church, an implementation of God's will.

Terrestrial Arteries



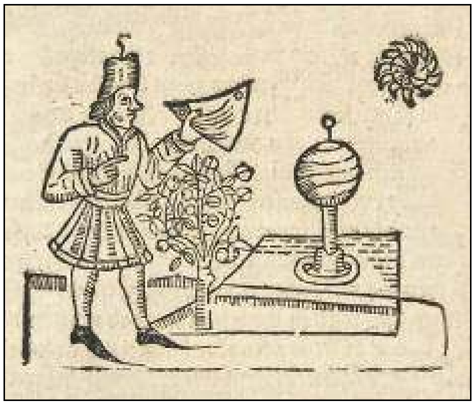
Plato's analogy between the "macrocosm" of the cosmos and the "microcosm" of humankind strives to reduce a complex universe into some intelligible scale, and thus give unity to the whole.

Aristotle was a crypto-biologist, seeing the earth a living organism. It took budding mechanists little effort to follow the philosopher's path -- a macrocosmic earth working as a microcosmic human body. Our schematic shows da Vinci’s drawing of a human heart.



Galen (129-199), the most significant physician of the ancient world after Hippocrates, believed in two separate “tides” of blood, the arterial and the venous, independently driven by the heart. Arteries carry the “vital” spirits to the tissues. Veins convey the “natural” spirits.

As an engine for underground rivers, Galen’s model of the heart -- pumping ever upward as it must -- made sense.



William Caxton (1422-1491), the first English printer, subscribed to the blood model in Mirror of the World, though the actual authorship remains unknown.

> *All is likewise as the blood of a man goeth out & issueth in some place, all in likewise runneth the water by the veins of the earth and soundeth and springeth out by the fountains and wells; from which it goeth all about that, when one delveth in the earth deep in meadow or in mountain or in valley, men find water.*

The centerpiece of da Vinci's world view was the earth as a living, self-sustaining organism. From his unfinished Treatise on Water,

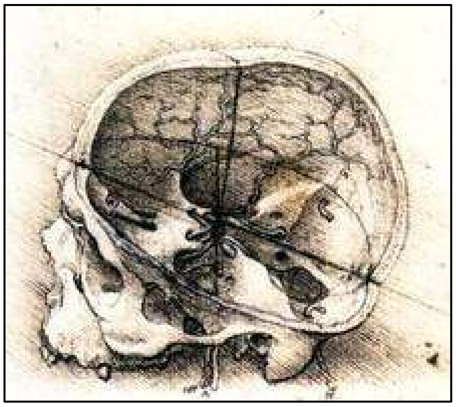
> *By the ancients man has been called the world in miniature; and certainly this name is well bestowed. Inasmuch as man is composed of earth, water, air, and fire, his body resembles that of the earth.*

Da Vinci seems to be preparing to argue for something transmutational, but instead he turns to metaphor.

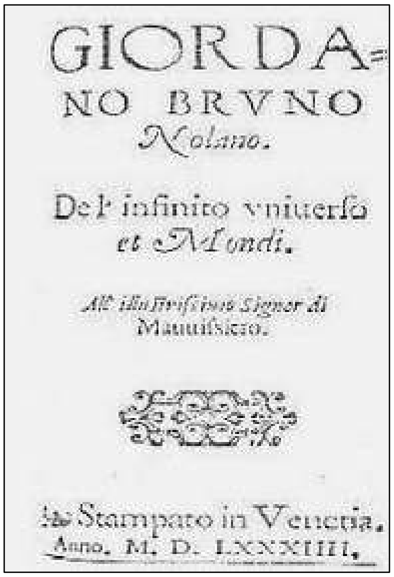
> *So that we might say*
> *That the earth has a spirit of growth;*
> *That its flesh is the soil,*
> *Its bones are the arrangement and connection of the rocks of which the mountains are composed,*
> *Its cartilage is the porous rock,*
> *And its blood is the springs of water.*
> *The pool of blood which lies round the heart is the ocean,*
> *And its breathing, and the increase and decrease of the blood in the pulses, is represented in the earth by the flow and ebb of the tide.*

Da Vinci recognized, however, the analogical difficulty. While both the globe and the human body consist of earth, water, air and fire, the correspondence of macrocosm to microcosm can only work if the globe possesses a mechanism comparable to the heart. Da Vinci came close discovering the circulation of blood, but in the end, could not break free from Galen.

> *Just as the natural heat of the blood in the veins keeps it in the head of man, and when the man is dead the sinks to the lower parts, and as when the sun warms the man's head the amount of blood there increases and grows so much with other humors, that by pressure in the veins it frequently causes pains in the head; in the same way with the springs which ramify through the body of the earth and, by the natural heat which is spread through all the -- containing body, the water stays in the springs at the high summits of the mountains.*



Giordano Bruno (1548-1600) considered geographical features not as accumulations of inert matter, but as spirits of life corresponding to the bones, intestines, veins, arteries, flesh and nerves of the earth. As explained in De l'infinito Universo et Mondi (1584), fog, rain, lightning, thunderstorms and earthquakes are terrestrial diseases. Without underground rivers, the world would perish for lack of blood. Bruno was burned at the stake for errors in theology.



GIORDA=
NO BRVNO
Nolano.

De l' infinito vniuerſo
et Mondi.

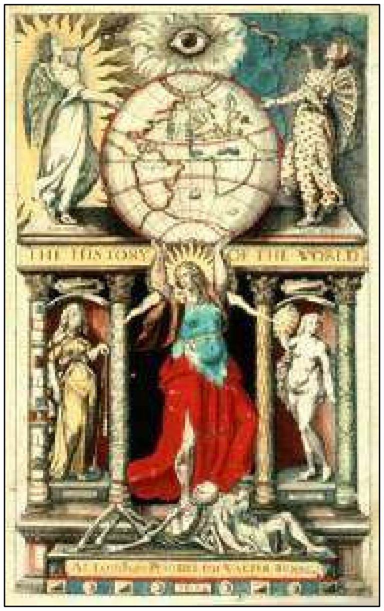
All' illuſtriſsimo Signor di
Mauuiſsiero.

Stampato in Venetia.
Anno. M. D. LXXXIIII.

Sir Walter Raleigh (1552-1618), remembered for his gallantry with Elizabeth I, promoted a doctrine of organic microcosm in The History of the World (1616), written while imprisoned in the Tower of London.

> [Man's] *blood, which disperseth itself by the branches of veins through all the body, may be resembled to those waters which are carried by brooks and rivers over all the earth, his breath to the air, his natural heat to the enclosed warmth which the earth has itself.*

Raleigh saw the hydrologic cycle as an illustration of God's power, the theme we'll pursue Chapter 13. Without Holy Power, nature would become "silent, virtueless, and dead."

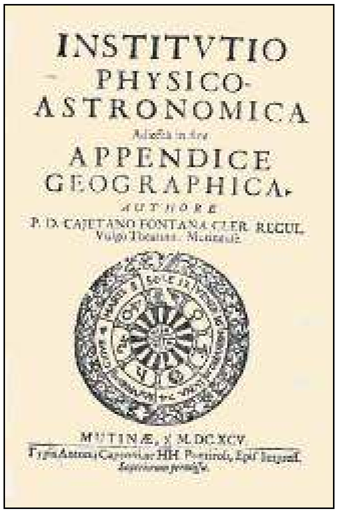

THE HISTORY OF THE WORLD

William Harvey (1578-1657) saw the pervasiveness of circular processes in nature as the noblest form of motion. Like Aristotle, Harvey believed that both sublunary bodies and living organisms aspire to the pattern displayed by the orbits of heavenly bodies. Harvey's Exercitatio Anatomica de Motu Cordis et Sanguinis (1628) drew attention to the hydrologic cycle.

> *The moist earth, warmed by the sun, evaporates; the vapors drawn upwards are condensed, and descending in the form of rain, moisten the earth again; and by this arrangement are generations of living things produced... And so, in all likelihood, does it come to pass in the body, through the motion of the blood; the various parts are nourished, cherished, quickened by the warmer, more perfect, vaporous, spirituous, and, as I may say, alimentive blood; which, on the contrary, in contact with these parts becomes cooled, coagulated, and, so to speak, effete; whence it returns to its sovereign the heart, as if to its source, or to the inmost home of the body, there to recover its state of excellence or perfection...* [All] *this depends on the motion and action of the heart... The heart, consequently, is the beginning of life; the sun of the microcosm, even as the sun in his turn might well be designated the heart of the world.*

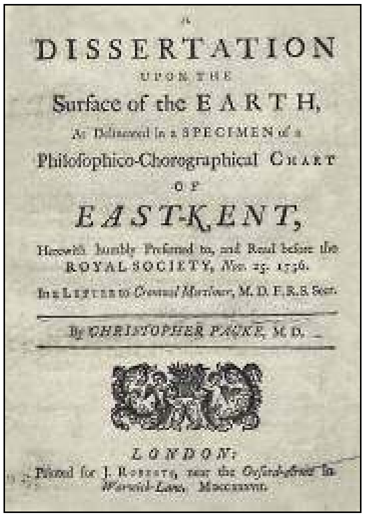
EXERCITATIO
ANATOMICA DE
MOTV CORDIS ET SAN-
GVINIS IN ANIMALI-
BVS,
GVILIELMI HARVEI ANGLI,
Medici Regii, & Professoris Anatomiae in Col-
legio Medicorum Londinensi.

FRANCOFVRTI,
Sumptibus GVILIELMI FITZERI.
ANNO M. DC. XXVIII.



INSTITVTIO
PHYSICO-
ASTRONOMICA
APPENDICE
GEOGRAPHICA.
AUTHORE
P. D. CAJETANO FONTANA CLER. REGUL.
MUTINÆ, M.DC.XCV.

Cajetano Fontana wrote in Instituto Physico-Astronomica (1695) that fountains rising within the earth are actuated by “anima of the Geocosmos,” the economy of nature, just as human blood is moved by the “anima” of vital principle.

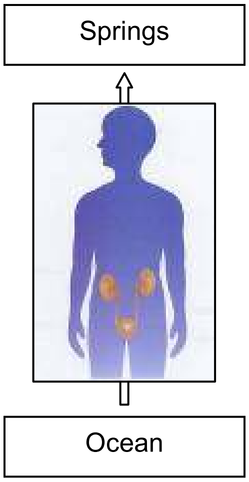


A
DISSERTATION
UPON THE
Surface of the EARTH,
As Delineated in a SPECIMEN of a
Philoſophico-Chorographical CHART
OF
EAST-KENT,
Herewith humbly Preſented to, and Read before the
ROYAL SOCIETY, Nov. 25. 1736.
In a LETTER to Cromwell Mortimer, M. D. F.R.S. Secr.
By CHRISTOPHER PACKE, M.D.
LONDON:
Printed for J. ROBERTS, near the Oxford-Arms in
Warwick-Lane, MDCCXXXVII.

Reluctant to be retired, the arterial analogy received a hearing in London's Royal Society as late as 1736 when Christopher Packe (1686-1749) commended glowingly the "concerted Regularity” of the valleys in Kent, likening them to the veins of the body, and hinted at a subterranean network of channels, "analogous to the arteries," published the year following as Dissertation upon the Surface of the Earth, as Delineated in a Specimen of a Philosophico-Chorographical Chart of East Kent.

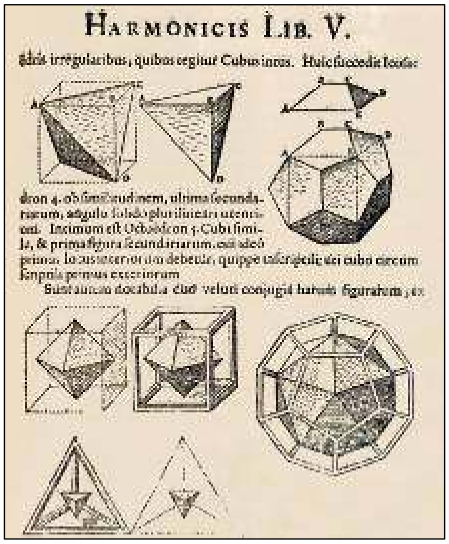
In retrospect, analogy to human blood wasn't bad science for Leonardo's day. It mimicked observable natural function and, like Newtonian physics, sought physical law independent of scale. The model's persistence for another two centuries is more difficult to justify, however.

The Urinary Tract



The urinary-tract model never got too far. Were it not associated with a respected scientist, we'd drop it from our list, but on the other hand, it's creative.

German astronomer Johannes Kepler (1571-1630) called the moving cause of planets an "anima motrix" (moving soul) in his Mysterium Cosmographicum (1596). Although in the second edition he replaced "anima" by "vis" (force), his Harmonices Mundi (1619) persisted with the metaphor.



HARMONICIS LIB. V.

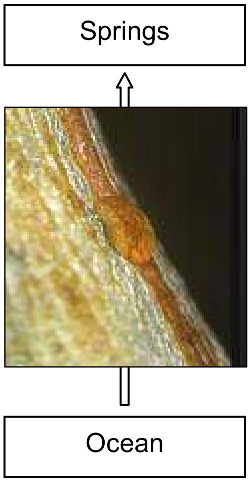
> *The globe contains a circulating vital fluid... Every particle of it is alive. It possesses instinct and volition and even the most elementary of its molecules, which attract and repel each other according to sympathies and antipathies. Each kind of mineral substance is capable of converting immense masses of mater into its own peculiar nature, as we convert our aliment into flesh and blood. The mountains are the respiratory organs of the globe, and the schists its organ or secretion.*

Kepler's metabolic model was well suited for the passage of subterranean waters.

> *The Earth forever drinks in water from the sea... and that groundwater and springs are the end products of the Earth's metabolism.*
>
> *As urine from the bladder, rivers flow from the mountains.*

Kepler is best remembered for his heliocentric laws of planetary motion, not his insight regarding geohydrology.

The Earth's Sap



While the early mechanists were more likely to envision the earth as an animal, not a vegetative organism, the vine metaphor was sometimes employed to describe underground streams.

Da Vinci suggested that spring water "rises from the low roots of the vine to its lofty head, falls through the cut branches upon the roots and mounts anew to the place whence it fell." His evidence was as follows.

> *The same cause which stirs the humors in every species of animal body and by which every injury is repaired, also moves the waters from the utmost depth of the sea to the greatest heights and just as the water* [sap] *rises from the inferior parts of the vine to the cuts higher up.*
>
> *Likewise the water that rises from the low roots of the vine to its lofty head falls through the cut branches upon the roots and mounts anew to the place whence it fell.*

> *As the water rises from the lowest part of the vine to the branches that are cut, so from the lowest depth of the sea the water rises to the summits of mountains, where, finding the veins broken, it pours out and returns to the bottom of the sea.*

We've modeled underground rivers powered by both transmutation and biology, but there are ever so many more possibilities.

CHAPTER 9
THERMODYNAMIC ENGINES

This chapter deals with underground rivers powered by heat, but in before we ignite the hearth, we need an ample reservoir of water.

Hydrophylacia

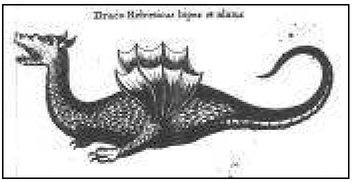
Athanasius Kircher (1602-1680), a prolific polymath, was the world’s first scientist to support himself through his writings. His syncretistic scholarship paid little attention to disciplines. A Jesuit living in an age still rocked by Reformation, Kircher heeded the Holy Scriptures, but from Kircher's viewpoint, a "Turris Babel" reaching the heavens seemed impractical. By his reckoning, it would require 3,000,000 tons of building material just to reach the moon. But worse, the edifice would pull the earth from the center of the universe.

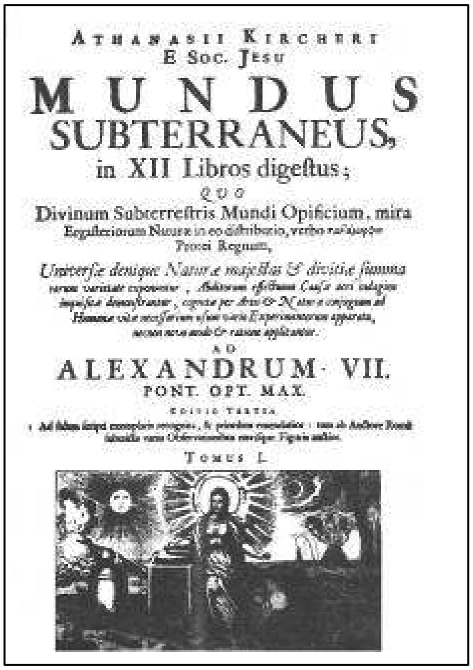
Kircher's two-volume Mundus Subterraneus (1665) was the first printed work on geophysics. Not constrained by its title, however, the work included maps of the solar surface, global ocean circulation and Atlantis.

Regarding the subterraneus,

> *The Underground World is a well framed house with distinct Rooms, Cellars, and Storehouses, by great Art and Wisdom fitted together.*

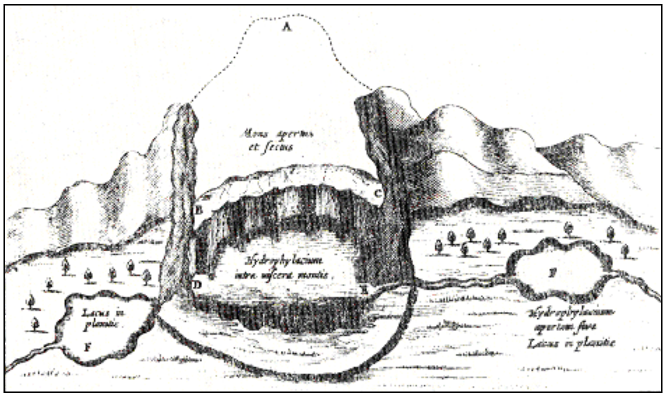
Kircher's theory of holes on the ocean floor connecting to underground brooks was embellished with mention dragons and gargantuan lizards.


Draco Helveticus bipes et alatus


ATHANASII KIRCHERI
E SOC. JESU
MUNDUS
SUBTERRANEUS,
in XII Libros digeſtus;
QUO
Divinum Subterreſtris Mundi Opificium, mira
Protei Regnum,
AD
ALEXANDRUM VII.
PONT. OPT. MAX.
EDITIO TERTIA
TOMUS I.

Kircher's most-dramatic contribution to geologic graphic art is the hollow-mountain water cavern, the "hydrophylacium," "phylacium" being Latin for "storehouse." That Kircher placed such caverns above sea level suggests that he believed them to drain by gravity.

Mundus Subterraneus was widely reprinted with altered graphics, but no matter the particular artist, the hydrophylacia are central to the composition. Three of the four illustrations shown here are geographically explicit.


A
Mons apertus et siccus
B
C
Hydrophylacium intra viscera montis
D
E
Lacus in planitie
F
Hydrophylacium apertum sive Lacus in planitie

OCEANUS
OCCIDENTALIS

OCEANUS
AETHIOPICUS
OCEANUS
ORIENTALIS
AFRICAE

GALLIA
GERMANIA
ITALIA
DALMATIA
Mare Gallicum
Mare Adriaticum

The hydrophylacia model was old, however, even in Kircher's era. Conrad von Megenberg's Das Buch der Natur (1349-1351), the first illustrated book on nature, included a description of the big-cavity hydrology.

> *Some* [waters] *originate in the big hollow mountain which is cold and rocky. The watery steam dissolves here into water drops which mix with the soil, with the daily rain and the snow. So the water drops collect in the cavities and form a rivulet; many rivulets form a big stream which seeks an exit from the mountain and eventually breaks through. This is the spring of flowing waters or of a well on the mountain, or a lake on the mountain.*

As the hydrophylacia are above sea level, Kircher needed to explain how seawater attained the elevation. The fact that that temperature increases with depth in dry mines guided his ideas.

> *The central fire pours out surging and burning exhalations to each and every part by fire-carrying channels. Striking the water-chambers it forms some into hot springs. Some, it reduces to vapors which, rising to the vaults of hollow caves, are there condensed by cold into waters which, released at last, give rise to springs and rivers.*

An event in 1678 seemed to support the existence of hydrophylacia. Flash flooding of the Garonne River, which issues from a spring in the Pyrenees, without there having been local rainfall, was attributed to collapse within the mountain displacing an underground lake.

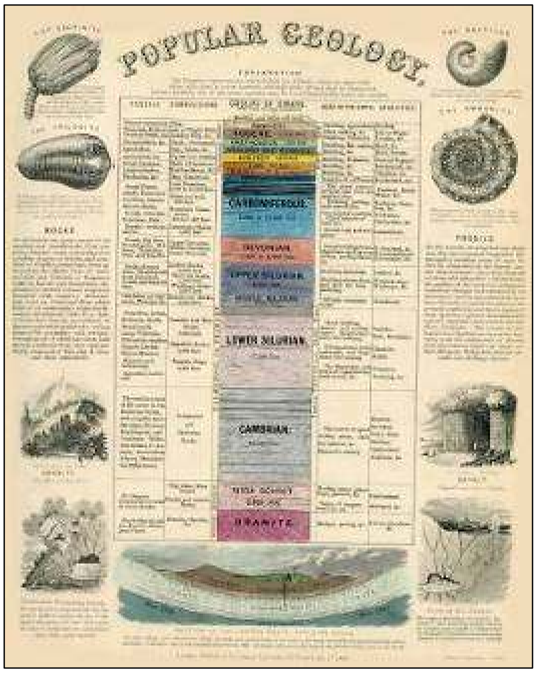
> *So this Mass of the Mountain in its settling all at once upon the Water of the Gulphs or Subterraneous Lakes, which are under the highest Pyrenean Mounts ... do force the Water to*

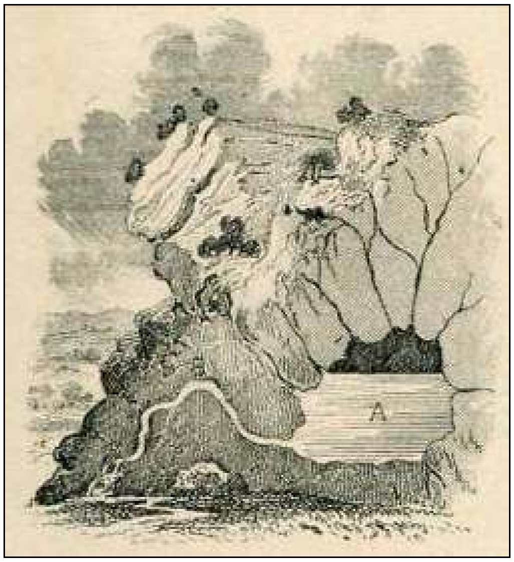
> *gush out all together with great violence to the same quantity with the Bulk of that part of the Mountain which is settled into the Subterraneous Lakes, which is the cause o/this Prodigious over flowing.*

A dye study described in Chapter 46 would later show the Garonne's subterranean reach involves no such hydrophylacium, but Chapter 46 wouldn't have been available at the time.

For centuries to follow, Kircherian drawings -- the cavernous hydrophylacia being a trademark -- have proven to be almost impossible to suppress. We cite, for illustration, "Popular Geology, a Complete Summary of the Science, with Many Illustrations," engraved by John Emslie, published in Reynolds' Twelve Geological Diagrams (1860), a portfolio of plates to be passed around a lecture hall or posted for edification.

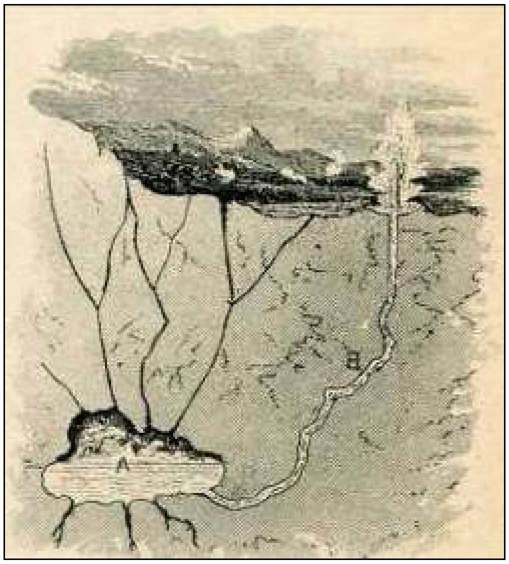
The enlargements of the lower left and right figures bear the hydrophylacia stamp of our irrepressible Jesuit.





Section of an Intermittent Spring

> *The rain by percolating the rock fills the cavity A until it reaches the top of the bend B, the spring will then flow until the water is exhausted, the same phenomena being again repeated.*



Section of a Geyser

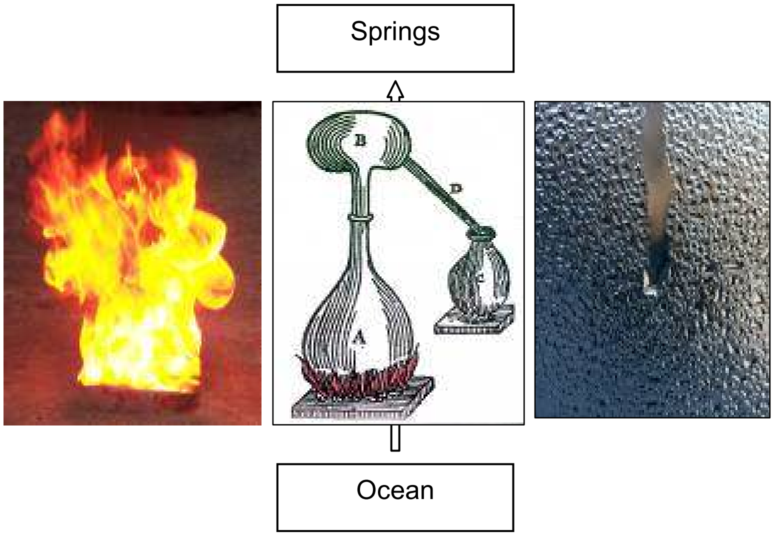
> *The water percolating the rock fills the cavity A and becoming greatly heated by volcanic action, steam is formed, which by its elastic force drives the water up the channel B whence it issues as a fountain.*

Descartes (Chapter 7), a Kircher contemporary who equated Jesuitical intellectualism with the Inquisition that imprisoned Galileo and executed Bruno, described Kircher as "more quacksalver than savant."

If Kircher was quacksalver -- a charlatan -- he was at least an engaging quacksalver.

A hydrophylacium may also be required for non-thermal geophysical engines of underground flow, but we'll get to those possibilities in the chapter to follow.

The Heat of the Earth



We show three mechanisms -- fire, an alembic and condensation -- which while together describing the same physical process, were differently emphasized by early writers.

Mt. Etna had a major eruption in 475 BC and another in 396. In 1669, lava destroyed the town of Nicolosi and Catania. Other pre-1800 eruptions occurred in,

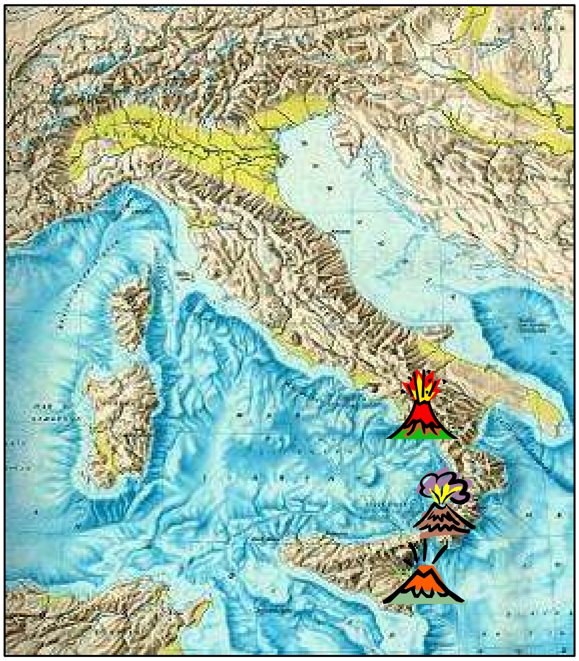
> 1797-1801, 1791-93, 1787, 1780-81, 1776, 1770, 1763-67, 1752-59, 1747-49, 1744-45, 1735-36, 1732-33, 1723-24, 1702, 1693-94, 1688-89, 1682, 1651-56, 1646-47, 1643, 1633-38, 1614-24, 1603-10, 1595, 1579-80, 1566, 1554, 1540-41, 1536-37, 1494, 1446-47, 1444, 1408, 1381, 1350, 1333, 1329, 1284-85, 1250, 1222, 1194, 1169, 1164, 1160, 1157, 1063, 1044, 1004, 911, 859, 814, 812, 644, 417, 252, 80, 39, 10 AD and 10, 32, 36, 44, 49, 56, 61, 122, 126, 135, 141, 350, 396, 424-25, 476-79, 565, 695, 735 and 1500 BC.

Mt. Vesuvius near Campania is one of the world's most dangerous volcanoes. Pre-1800 eruptions occurred in,

> 1796-1822, 1783-94, 1770-79, 1764-67, 1744-61, 1732-37, 1724-30, 1712-23, 1706-08, 1701-04, 1696-98, 1685-94, 1682, 1654-80, 1637-52, 1631-32, 1500, 1347, 1270, 1150, 1139, 1073, 1049, 1037, 1007, 999, 991, 968, 787, 685, 536, 512, 505, 472, 379-95, 222-35, 203, 172, 79 AD and 1500 BC.

The Island of Stromboli, north of Sicily, has been in almost continuous eruption for over 2,000 years. Larger than normal eruptions over the recent 240 years include those of,

> 2006, 2003, 1998-2000, 1993-96, 1989-90, 1985-1986, 1975, 1971, 1966-68, 1959, 1956, 1949-54, 1943-44, 1941, 1936-37, 1934, 1930, 1919, 1915, 1912, 1905-07, 1903, 1900, 1895-98, 1891-1893, 1888-89, 1885, 1881-82, 1879, 1874, 1855, 1850, 1833, 1822, 1778, 1770 and 1768.



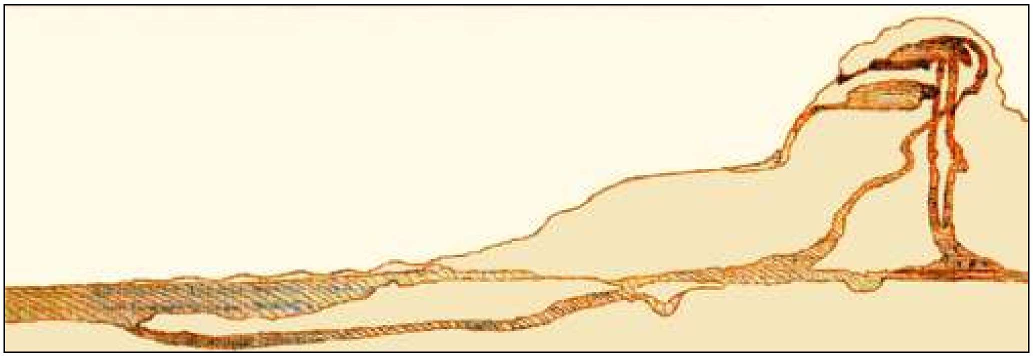
To speculators steeped in classical history, the earth's igneous power seemed more than sufficient to pump hillside fountains. Da Vinci argued initially that water is drawn upwards through subterranean passages by the heat of the sun, but the heat source did not please da Vinci for two reasons.

As mountain crests are closer to the sun, flowing water shouldn't be frigid.

The solar engine should work best in the summer when water is warmer, but the summer is often when springs diminish.

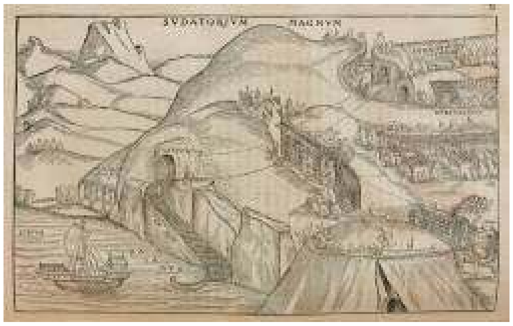
Aware of the 1494 Mt. Etna eruption and the 1500 event of Mt. Vesuvius, da Vinci turned toward an interior fire as a better explanation of spring water.

> *Now the same heat which holds up so great a weight of water as is seen to rain from the clouds, draws them from below upwards, from the foot of the mountains, and leads and holds them within the summits of the mountains, and these finding some fissures, issue continuously and cause rivers.*
> *And this water, which passes through a closed conduit inside the body of the mountain like a dead thing, cannot come forth from its low place unless it is warmed by the vital heat of the spring time. Again, the heat of the element of fire and, by day, the heat of the sun, have power to draw forth the moisture of the low parts of the mountains and to draw them up, in the same way as it draws the clouds and collects their moisture from the bed of the sea.*



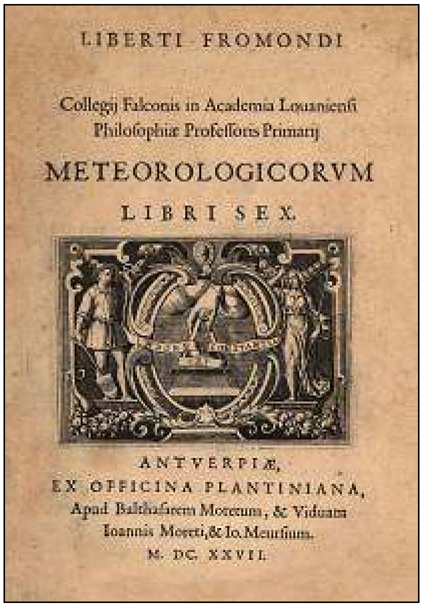
Da Vinci suggests how seawater can rise toward a mountain peak because of subterranean fire.

> *The heat of the spirit of the world is the fire which pervades the earth, and the seat of the vegetative soul is in the fires, which in many parts of the earth find vent in baths and mines of sulphur, and in volcanoes, as at Mount Aetna in Sicily, and in many other places.*



Georg Bauer (1494-1555), "Agricola," recognized in De Ortu et Causis Subterraneum (1546) that springs are largely supplied by rainwater, but,

> *Being heated it can continually give off halitus* [steam]*, from which arises a great and abundant force of waters. Halitus rises to the upper parts of the canales, where the congealing cold turns it into water, which by its gravity and weight again runs down to the lowest parts and increases the flow of water if there is any.*
>
> *If any find its way through a canales dilatata* [expanded] *the same thing happens, but it is carried a long way from its place of origin. The first phase of distillation teaches us how this water is produced, for when that which is put into the ampulla is warmed it evaporates, and this balitus rising into the operculum is converted by cold into water, which drips through the spout. In this way water is being continually created underground.*
>
> *And so we know from all this that of the waters which are under the earth, some are collected from rain, some arise from balitus, some from river-water, some from seawater; and we know that the halitus is produced within the earth partly from rainwater, partly from river water, and partly from seawater.*



LIBERTI FROMONDI

Collegij Falconis in Academia Louaniensi
Philoſophiæ Profeſſoris Primarij

METEOROLOGICORVM
LIBRI SEX.

ANTVERPIÆ,
EX OFFICINA PLANTINIANA,
Apud Balthaſarem Moretum, & Viduam
Ioannis Moreti, & Io. Meurſium.
M. DC. XXVII.

In Meteorologicorum Libri VI (1627) Belgian Libert Froidmont (1587-1653) described mountains as alembics, a distillation apparatus familiar to alchemists.

ARCHITETTVRA
D' ACQVE
DI
GIO. BATTISTA BARATTIERI
INGEGNERE.
PARTE PRIMA

FERDINANDO SANTI

PIACENZA

In his Architettura d'Acque (1656), Giovanni Battista Barattieri endorsed the geological alembic, although he included melting snow's contribution to springflow based on observation.

On a visit to southern Italy, Kircher -- who surely knew of the igneous demise of Pliny the Younger (Chapter 3) -- was lowered into the crater of Mt. Vesuvius, then on the brink of eruption, to examine its interior. More fortunate than Pliny, the Jesuit emerged alive.

The driving force in Mundus Subterraneus is the central fire, diffusing with igneous exhalations heated water from hydrophylachia filled with water, fog or air converted to steam, which, in turn rise to the highest mountains.

> [The] *Associates, and Agents of Nature* [fire and water] *sweetly conspire together in mutual service, with an inviolable friendship and wedlock, for the good of the whole in their several and distinct private-lodgings...* [creating] *minerals, juyces, marles, glebes, and other soyls, with ebullitions, and bubblings up of fountains.*

Kircher accused Aristotle of opposing scripture by denying that springs and rivers originate in the sea, but remained Aristotelian in terms of causal structure.

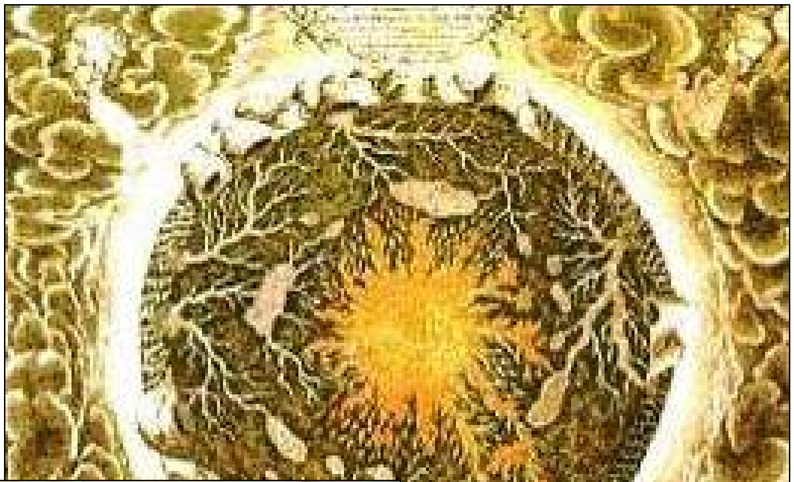
The formal cause is fire.

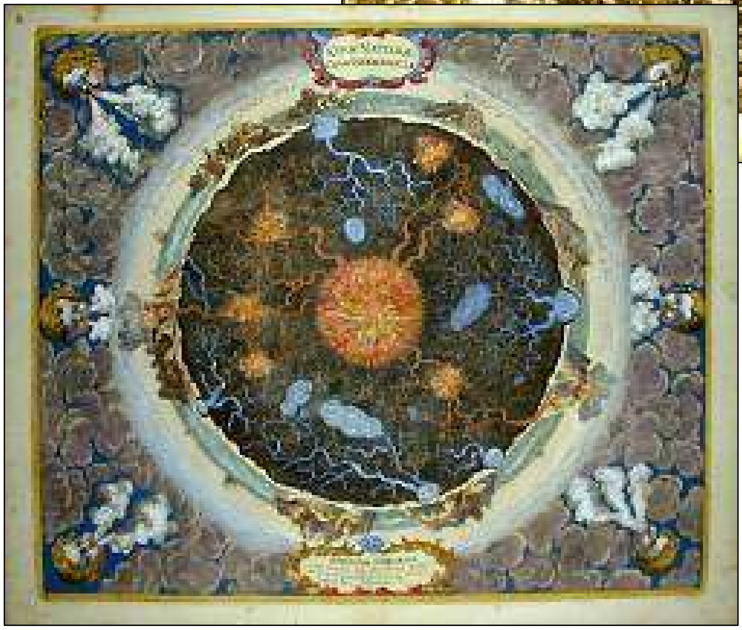
The material cause is “Sulphur, Bitumen, Pit-Coals, and also Allom, Salt, Nitre, Coaly Earth, and Calcanthum or Vitriol, and such kind of Metals.” in the dark recesses.

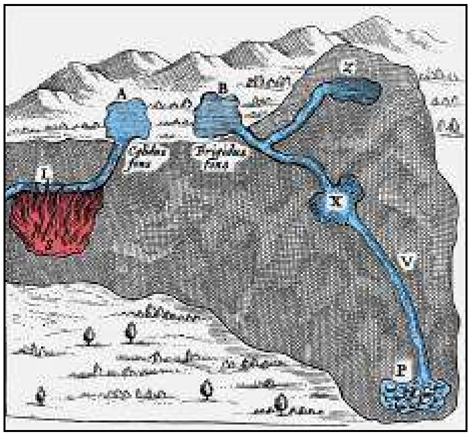
The instrumental cause is “the Cavernous nature of the place... oppressed with Sulphureous Smoak and Soot.”

The efficient cause consists of “Winds and Blasts” from the cavernous interior.

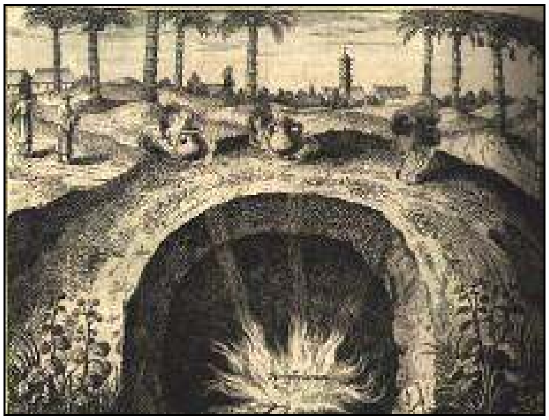
Kircher's graphics catch the flavor of the fiery underground. Pyrophylacia (fire caverns) connect with the earth’s "central fire" through a network of chambers, underground reservoirs, fountains and twining passages through which water and lava escape to the surface.







Kircher included the seabed as a source of springflow because snow and rainfall are seasonal, whereas rivers are not. To disprove the mechanism of subterranean condensation, he referred to the lake at Mt. St. Gotthard lacking the covered vault that condensation would necessitate.



As an orientologist (among his myriad of interests), Kircher pursued repots from his fellow Jesuits regarding far-off Asia. His illustration in China Monumentis (1667) is another case of the fiery global engine.

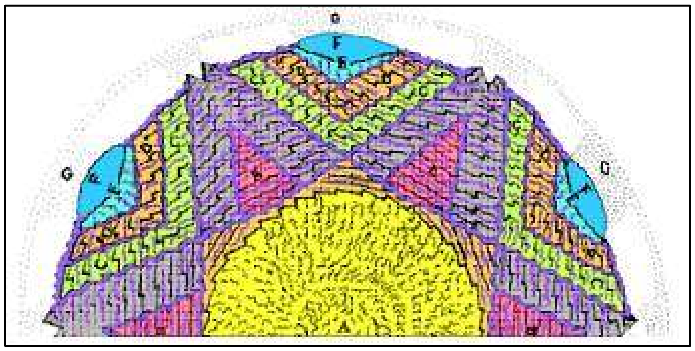
Thomas Robinson's The Anatomy of the Earth (1694) and New Observations on the Natural History of the World of Matter (1696) described vapors from the sea condensing into mountain showers that cause rivers to flood. Other waters move upward through a maze of subterranean “dikes” to mountain tops where they emerge as springs.

Robinson rehashed da Vinci’s analogy between the bursting forth of mountain top fountains and the breaking of a blood vessel. Mountain tops, Robinson instructs, are more subject to accidents (tempests and thunder) than are flat plains where the veins are thickly buried.

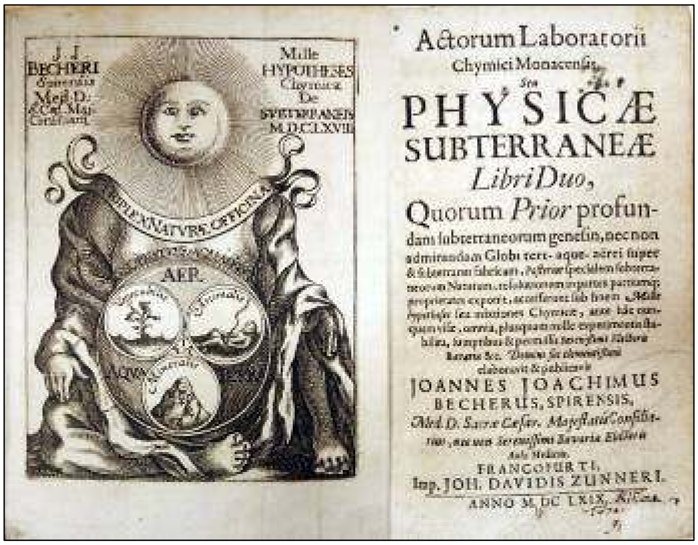
> *The windings and turnings of the greater Veins... through which the whole mass of subterranean Water Circulates. The Lesser Fibers, or Ramifactions, filling all the flat Strata with feeders of Waters, which breaking out upon the Surface of the Earth cause Springs.*
>
> *And thus, in our Bodies, ‘tis much easier to break a Vein in the Neck or Arm, where they lye nearest the skin; than in the Buttocks, or any other such Fleshy-part.*

Robinson's diagram explains the matter.

A	Central Fire
B	Mountains
C	Heaths
D	Plains
E	Channels of the Sea
F	Seas with rivers flowing into them from the tops of mountains “swelling them into a Gibbosity and causing in them a Continual Fermentation.”
G	Vapors arising from the Seas



Johann Joachim Becher's theory, put forth in Physica Subterranea (1669), placed the evaporation in a single cavity at the globe's center, the Abyss, not in individual caverns beneath mountains. Condensation, on the other hand, mostly occurs inside mountains because hills are more cavernous than the rest of the earth.



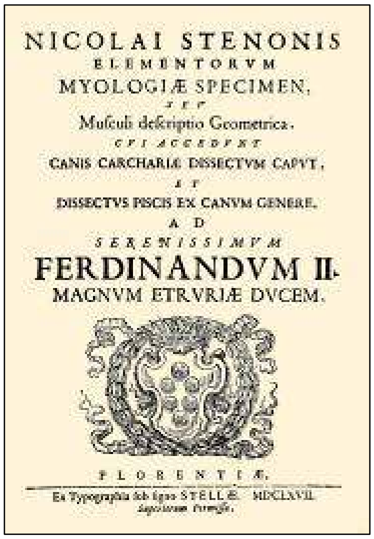
J. J.
BECHERI
Mille
HYPOTHESES
AER.
AQUA

Actorum Laboratorii
Chymici Monacenſis,
Seu
PHYSICÆ
SUBTERRANEÆ
Libri Duo,
Quorum *Prior* profun-
dans ſubterraneorum geneſin, nec non
admirandam Globi terr- aque- aerei ſuper
& ſubterranei fabricam,
JOANNES JOACHIMUS
BECHERUS, SPIRENSIS,
FRANCOFURTI,
Imp. JOH. DAVIDIS ZUNNERI.
ANNO M. DC LXIX.

The first occasion on which the condensation theory can be traced to actual observation in a cave was when Nicolas Steno (1638-1686) wrote in Canis Carchariae (1669)

> *I have seen an abundance of water dropping from many caverns where every part of both roof and floor was solid.*

The water could not have come through the rock but must have "condensed from the upper atmosphere ... which I believe is very common."



NICOLAI STENONIS
ELEMENTORVM
MYOLOGIÆ SPECIMEN,
SEV
Muſculi deſcriptio Geometrica.
CVI ACCEDVNT
CANIS CARCHARIÆ DISSECTVM CAPVT,
ET
DISSECTVS PISCIS EX CANVM GENERE.
A D
SERENISSIMVM
FERDINANDVM II.
MAGNVM ETRVRIÆ DVCEM.

FLORENTIÆ,
Ex Typographia ſub ſigno STELLÆ. MDCLXVII.
Superiorum Permiſſu.

Apart from their comparisons of rainfall and streamflow, Perrault and Mariotte (Chapter 12, Superterranean Metrics) discussed how springs could maintain a reasonably-constant rate. Perrault, perhaps influenced by Steno, argued the case for subterranean condensation in De l'Origine des Fontaines (1674).

> *It is reasonable to believe therefore that in the earth evaporation takes place which can produce water, either through heat communicated by the Sun ... or by cold or by currents of air within the earth, The water which occurs in caverns and channels at the foot of mountains is thus raised inside them to their summits where, because of the numbing induced by the cold which it encounters, is reduced to little drops of water, which join with each other" and so appear as springs.*

In The Motion of Water and Other Fluids ... Being a Treatise of Hydrostaticks (1718), Mariotte dismissed the capacity of condensation, and in any case "it is deny'd that there are many such hollow places in mountains," a refutation of the entire hydrophylacia concept.

The alembic theory of mountain springs faded, but as will be noted in Chapter 45, Subterranean Geophysics, the fiery-earth model is part-and-parcel of modern geophysics.

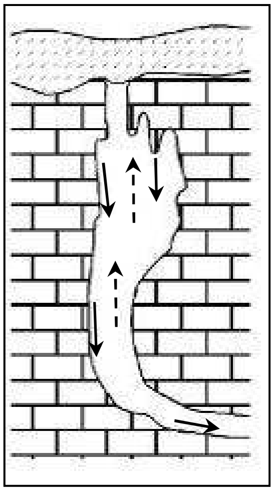
A fire smoldering within a cavern nicely, if incorrectly, explains the report in Adams County [Iowa] Free Press, October 18, 1913.

> *A peculiarity of some of the streams on Switzerland is that a number of them have their source from canyons which are underground passages. One at Ragaz, known as the Taminaschlucht, comes out at the foot of a mountain, and a foot way has been constructed so that it may be entered for a distance of about half a mile to a place where the stream gushes our of a subterranean opening to its full capacity, and at one side there is a second opening from which hot water flows.*

The Taminaschlucht gorge is 100 meters deep and 10 meters wide. A tunnel leads to a grotto having a 37°C thermal spring.

In at least this instance, hypothesizers of hot and cold subterranean plumbing were close to the mark.

What we now know of geophysics supports in loose degree even a transmutational basis for springflow, if one allows chemical reactions to count as transmutation. Some hot-spring effluent is "juvenile," newly formed by volcanic or tectonic processes.



While condensation may be inconsequential in most groundwater environments, again the early speculators were onto a legitimate idea.

The micro-hydrologic water balance in large cave systems -- especially ones in which there are large differences in temperature -- can be significant. In certain Crimean and Caucasian karst regions, between 0.1 and 20 percent of dry-season runoff is said to be derived from subterranean condensate, the illustration to the right serving as an illustration.

The heat of the earth does not drive underground rivers uphill, but in limited cases, geothermal energy plays a role in groundwater flow. The hydrophylacia so well advertised by Kircher do not exist, but again in limited cases, Chapters 51 and 42 containing examples, mammoth subterranean caverns evidence subterranean streamflow.

And we're not done with subterranean hydrologic engines, or at least imaginative propositions for the task.

CHAPTER 10

GEOPHYSICAL, PNEUMATIC AND ELECTROMAGNETIC ENGINES

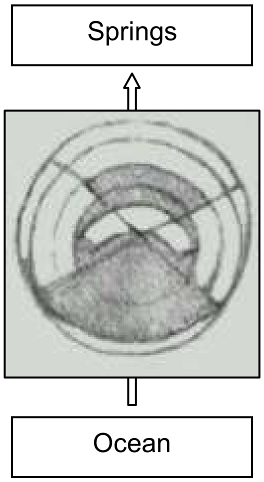
This chapter concludes our survey of misdirected explanations for the mechanism of subterranean streamflow. We will discuss nine additional hypotheses, all physically based, at least in superficial sense. The flaws in some schemes are apparent to the modern eye; others may appear plausible until a few numbers are crunched. All, however, made sense to progressive thinkers of their own day.

Our engines will derive from

Terrestrial Asymmetry,
The Weight of the Sea,
Siphoning,
Sloshing,
The Earth's Compressibility,
Capillary Action,
Earthquakes,
Pneumatics and
Electromagnetism

While several of the above inter-relate, their proponents may not have recognized the relation and we wish to do our best to look -- at lest for a moment -- through the eyes of the advocates.

Terrestrial Asymmetry



If the sea were higher than the land, ocean water would flow downhill to the mountaintops.

Job 37:10, Jeremiah 5:22 and Proverbs 8:29, assuring that God fixed the sea’s boundaries so that it will not overflow the land, were sufficient to satisfy the curiosity of most medieval thinkers gazing from the shore. The eye arbitrates what seems level and the arc of horizon indeed looks high.

But for Christians drawn to natural philosophy, there must be a physical rule to which the Biblical speaks.

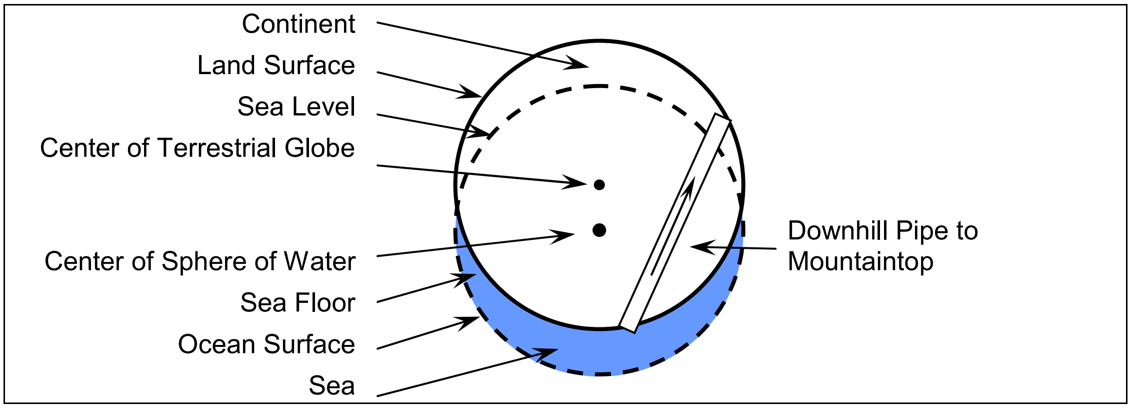
The first physically-based theory of the separation of sea and land was a marvelous exercise of human intellect. Jean Buridan (1295-1358) was a disciple of William of Ockham, remembered for the principle of ontological parsimony, Ockham's Razor.

> Entia non sunt multiplicanda praeter necessitatem.
> When competing explanations seem equally plausible, the simpler is more likely to be correct.

In Compendium totius Logicae, Buridan proposed that the earth is asymmetric, such that land occupies most of one hemisphere and oceans occupy primarily the other (plausible, given the geographic knowledge of the day). The geocentric requirement of his times -- that the earth lies at the center of the universe -- posed a problem, however, as sediment accumulation at the bottom of the sea would shift the earth's center of mass. To remain universally centered, the earth must thus shift as a whole towards the land hemisphere, raising it out of the water and thus rebuilding the mountains.

Albert of Saxony (1316-1390), primarily a logician (as opposed to a natural philosopher) extended the offset-spheres model. Appealing to the authority of his "revered masters from the Faculty of Arts at Paris," his Quaestiones in Aristotelis Libros de Caelo et Mundo explained earthquakes, tidal phenomena, and geology in terms of an "asymmetry preordained by God since eternity for the good of animals and plants."

Da Vinci's off-center geosphere didn't require God's ordination. The figure below, a labeled version of the sketch he used to illustrate the idea, shows why the sea remains offshore, and why the pipe is downhill from ocean to mountain slope.


Continent
Land Surface
Sea Level
Center of Terrestrial Globe
Center of Sphere of Water
Sea Floor
Ocean Surface
Sea
Downhill Pipe to Mountaintop

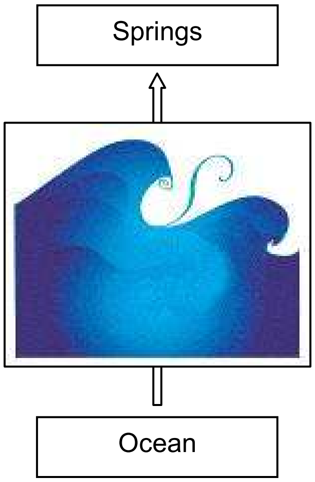
> *Perhaps you will say that water can only rise the same distance as it descends; and that the surface of the sea is higher than the summits of the highest mountains. The answer to this is that the exact opposite is the case, for the lowest part visible to the sky is the surface of the sea, since water does not move of itself unless to descend, and so descends when it moves; as therefore the rivers which stretch from the summits of the mountains to the sea are everywhere in movement they are therefore everywhere descending, and when they come to the sea they stop and end their movement; for which reason one must conclude that they arc stationary in the lowest reaches of the river.*

In another twist of the higher-than argument, da Vinci argued,

> *The Mediterranean Sea, a vast river placed between Africa, Asia, and Europe, gathers within itself about three hundred principal rivers, and in addition to that it receives the rains which fall upon it over a space of three thousand miles. It returns to the mighty ocean its own waters and those that it has received; but doubtless it returns less to the sea than what it receives; for from it descend many springs which flow through the bowels of the earth and vivify this terrestrial machine. This is so because the surface of this Mediterranean is farther from the centre of the world than the surface of this ocean.*

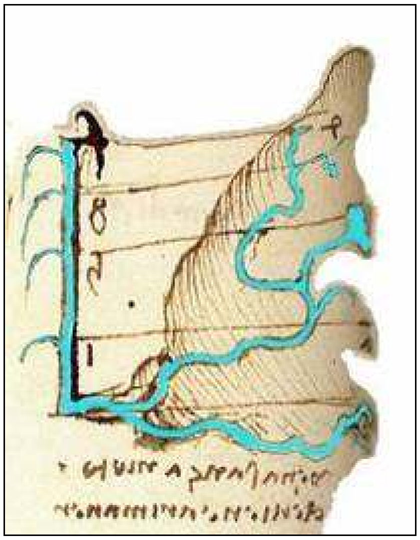
It would take the simplicity of Newtonian physics to explain that even if the earth were asymmetrical (which to some degree it is), there's only one downhill direction.

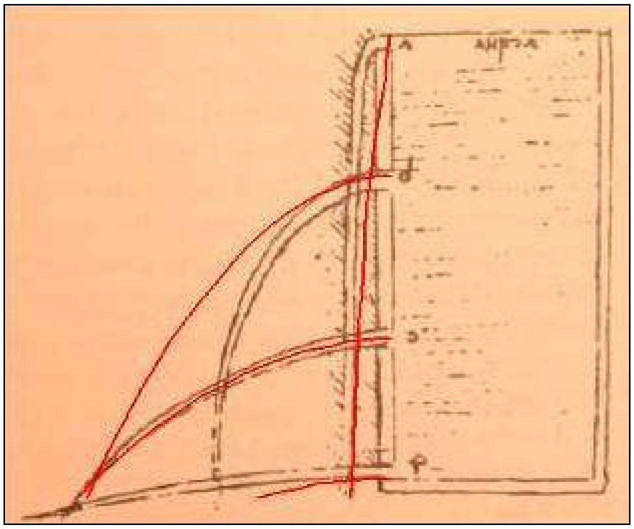
Weight of the Sea



Perhaps the sea's very weight propels underground rivers. Heraclitus, a Greek we met in Chapter 2, was onto the concept, but again we'll jump to da Vinci.

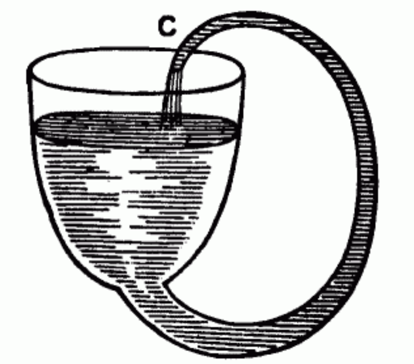
Da Vinci's two illustrations of hydrostatic pressure are shown below. The sketch on the left, clearly representing underground channels, is fundamentally incorrect, as the parabolic outflow trajectories are independent of elevation. The right-hand sketch, however, catches the distinction. The red overlay shows what hydrostatic theory predicts.





Aristotelian humanist Julius Caesar Scaliger's (1484-1558) posthumous Commentaries on Theophrastus' de Causis Plantarum (1566) argued that springs result from the infiltration of sea water into the earth under the pressure of the oceans.

Daniel Sennert (1572-1637), Célèbre Professeur de Médecine à Wittenberg proposed in Epitome Naturalis Scientiae (1651) that aided by tides, the weight of the ocean could push water to the mountain tops.



It's the "hydrostatic paradox" in which the larger weight on the diagram's left forces water down and around the narrow neck where the weight is less, pushing it up and from the orifice at the top.

The weight-of-the-sea hypothesis wasn't long held, however.

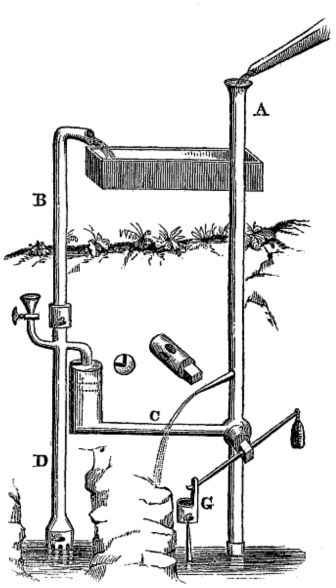
Robert Fludd (1574-1637) was an influential “kabbalist,” an alchemist in modern parley. The “chaotic four elements” in his theory of Macrocosm and Microcosm were heat, chill, moisture and dryness. The four aspects are heat (life), light (mind), electricity (kamic), and the synthetic essences.

DE NATVRÆ SIMIA SEU
AVTHORE

De Naturae Simia Seu Technica Macrocosmi Historia (1618)

A water-powered pump was described by Fludd in De Naturae Simia Seu Technica Macrocosmi Historia, likely inspired by what he may have observed in German mine works. While Fludd is remembered for his esoteric theories, this particular machine not a scheme for perpetual motion.

To the right, a sketch of Fludd's pump from Descriptive and Historical Account of Hydraulic and Other Machines for Raising Water (1850) by Thomas Ewbank. Water is dumped in at a given elevation and water from another source (presumably of better quality) is drawn up to a lower elevation. To put it concisely, A is above B.



No. 160. Pressure Engine from Fludd. A. D. 1618.

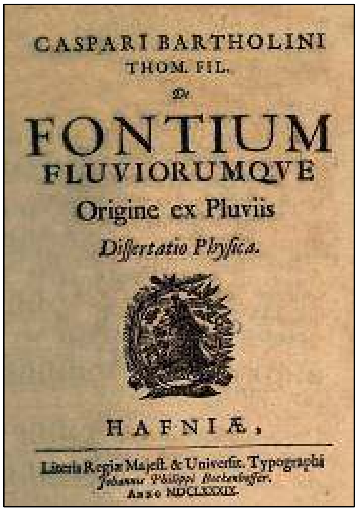
We include the pump as evidence that by the 17th century, even a kabbalist was aware that a closed system consumes more energy than it yields.

In De Fontium Fluviorumque Origine ex Pluviis (1713), Danish naturalist Thomas Bartholini (1616-1680) saw the same constraint.

> *Furthermore, that no fountains ever burst forth at the summit of a mountain, or near its head; but that always some portion of still higher land from which water may be supplied to them, overtops the fountains.*

Another subterranean motor discarded.

Discarded, but to yet lurk.



CASPARI BARTHOLINI
THOM. FIL.
De
FONTIUM
FLUVIORUMQVE
Origine ex Pluviis
Dissertatio Physica.

HAFNIÆ,
Literis Regiæ Majest. & Universit. Typographi
Johannis Philippi Bockenhoffer.
Anno MDCLXXXIX.

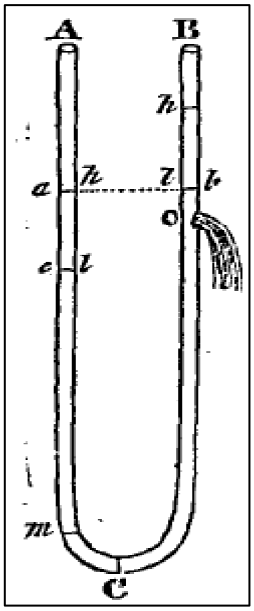
Following are two pieces from the 1800s, long after the weight-of-the-sea model had been refuted by Newtonian physics. Refuted, perhaps, but still marketable.

From "On the Cause of Fresh Water Springs, Fountains, &c.," American Journal of Science and Arts, July 1828, by Joseph Du Commun,

> *In the Harmony Gazette, November 21, 1827, there is a "Nut for the philosophers," picked, it is said from the National Gazette. I have endeavored to crack it, and I now present you with the kernel, leaving to your taste to determine whether it is palatable.*
>
> *The questions proposed are two in number, 1st, Why the fresh water issuing from the depth of two hundred and twenty feet, by boring in solid rock near the city of New Brunswick, rises from eight to fourteen feet above the surface of the Raritan river? and 2d, Why the quantity of water corresponds exactly and continually with the rising and falling of the tide?*
>
> *If we take an inverted glass siphon ACB and pour water into it, the two sides will be filled in part, and the water will rise in each side to the same height, say a and b.*

Note the "inverted." While Du Commun's overall argument may be faulted, the adjective, as we will note in Chapter 44, is correctly employed.

> *If instead of water, we introduce mercury in the branch A and rain water in the branch B, one inch of mercury at m will support above thirteen inches of water in the branch B.*
>
> *And lastly, if in the branch A we have a fluid denser than common water, as salt water for instance, the column of fresh water will be supported in the branch B, at the height b, by a column of the salt water inferior to it in height, in the inverse ratio of their densities, say to the height c only.*
>
> *But now, cannot the branch B, of our siphon represent the subterranean stream winding through the crevices of the rocks, until it reaches, at some depth or other, the great oceanic reservoir, and cannot the column of salt water in the branch A represent, in like manner, the height and pressure of the salt water of the ocean?*



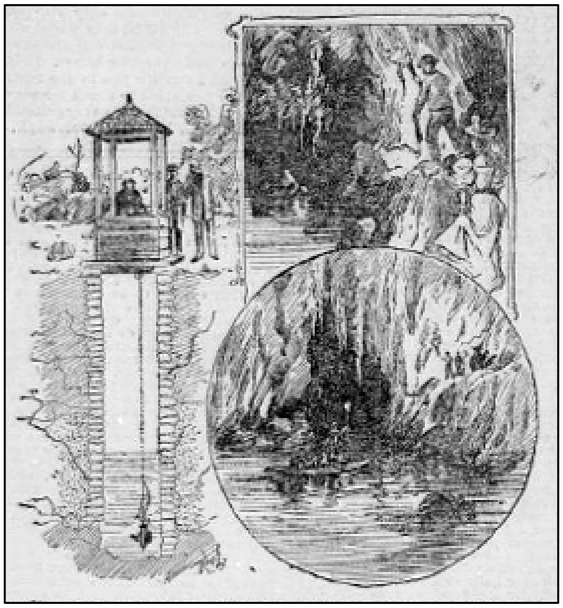
> *If so, it explains why the fresh water, in boring by the sea shore, is raised and flows above the level of the sea water; thus, one of the two given questions seems to be solved.*
>
> *The answer to the second may be deduced from the same principle.*

> *Let us suppose that a hole has been opened in the branch B, a little below lb the level of the water at ebb; the water will then flow with a velocity that may be represented by l, but at high tide the water might be supported at the height h, if the opening in the tube did not permit it to flow out, and it then must flow with the same velocity as if pressed under a column of fluid of that elevation. The quantity of water so running may be as 3, 4, 5, &c. according to the height of the tide; and finally, it must continually and exactly follow its oscillations.*
>
> *To these considerations several might be added, for example: Knowing the proportional densities of the fresh water and the sea water, and the difference of the two levels, to determine at what depth the subterranean stream empties itself in the ocean. If we calculate the particular case here given, we shall find, the density of fresh water being represented by 1000, that of sea water by 1029 (Dr. Murray,) the difference of the levels being fifteen feet, we shall find, I say that the depth at which they join under ground must be five hundred feet.*
>
> *Thence it follows, that if the junction of the two different kinds of water should take place at five thousand feet, or one mile, below the surface, the fresh water should rise at one hundred and fifty feet; if at fifty thousand feet, or ten miles, as one thousand five hundred feet, &c. This I think may account for the springs on high ground, and even at the top of insulated mountains.*

Though diagram is hydrostatically correct; its hydrodynamics are not. Once the U-tube equilibrates, fresh (i.e., less dense) water ceases to enter.

Were the ocean the cause of springflow, it stands to reason that tidal effects would be noted. From "Wonderful Underground Streams," Salt Lake Herald, August 22, 1897,

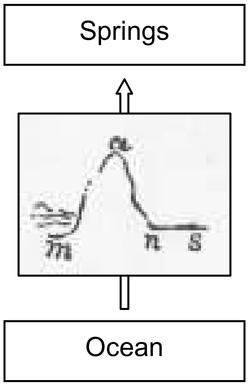
> *A remarkable new theory concerning the nature of parts of the earth's interior has just been promulgated by Professor F.H. King agricultural physicist of the University of Wisconsin. It is to the effect that the subsurface of the human footstool is interpenetrated by water incessantly in motion that there is a vast network of underground rivers, brooks, streams, pools and rivulets constantly flowing in various directions, some shallow, some deep, some near the surface some far below the outer crust, all of them having a definite tidal motion and all subject to lunar influence.*
>
> *It is not stated whether there is any intimate connection between these underground streams and the great streams and bodies of water which exist on the surface except that they are both governed by lunar influence and that the natural process of percolation may indirectly connect them with each other... It is a contention of Professor King that the underground waters embrace a world wide zone. They are not, therefore, confined to the United States alone but undermine the surfaces of Europe, Asia, Africa and Australia as well. Professor King is working to perfect a map of the underground streams of the world and as soon as he has finished we shall doubtless know more of what the interior of the earth is like.*



To the right, "Recording Oscillations of Underground Streams with a Chronograph."

The promised map and chronographic measurements are yet to be published.

Siphoning



Da Vinci liked the idea of siphoned underground waters. It's his artwork in the graphic.

> *The water of the ocean cannot make its way from the bases to the tops of the mountains which bound it, but only so much rises as the dryness of the mountain attracts. And if, on the contrary, the rain, which penetrates from the summit of the mountain to the base, which is the boundary of the sea, descends and softens the slope opposite to the said mountain and constantly draws the water, like a siphon which pours through its longest side, it must be this which draws up the water of the sea.*

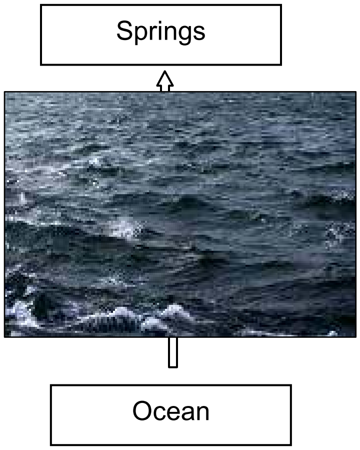
"Which pours through its longest side" indicates that da Vinci understood the principle.

> *Thus if s-n were the surface of the sea, and the rain descends from the top of the mountain a to n on one side, and on the other sides it descends from a to m, without a doubt this would occur after the manner of distilling through felt, or as happens through the tubes called siphons.*

“Distilling through felt” would seem to refer to capillary action, a mechanism discussed shortly, but da Vinci was one to cover all bases.

Much more has been speculated regarding siphoned springflow, but for that we'll wait until Chapter 44. Needles to say, of course, is that it doesn't trump gravity.

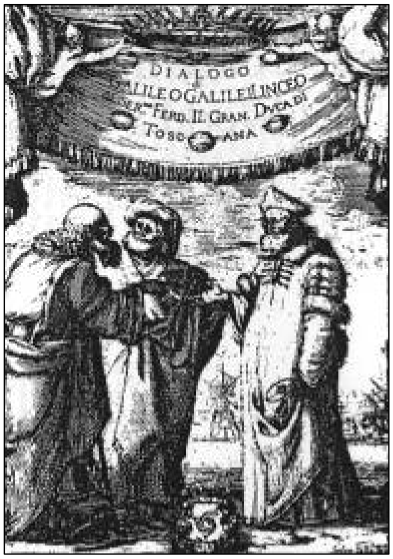
Sloshing



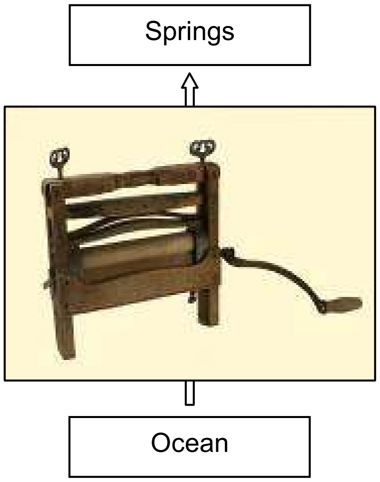
Of Kircher's several -- and sometimes conflicting -- geologic explanations for springflow, one involves seawater drawn into the earth's interior at the North Pole and expressed at the South Pole. (We've a map of the route in Chapter 15, The Maelstrom, and will thrill to tales of adventurous descents into such passages in Chapters 16-25) Subterranean sloshing causes the tides which in turn surge seawater through hidden channels to upland springs. High winds hasten the process

Kircher wasn't alone in the idea of sloshing seas. The working title for Galileo Galilei's Dialogue Concerning the Two Chief World Systems (1632) was Dialogue on the Tides in which he attributed tidal action to water sloshing due to the Earth's movement around the sun.

Galileo's interest was of, course, far above the earth sciences, but where an observation related to the latter might bolster the case for heliocentrism, Galileo found hydrology to be a useful science..

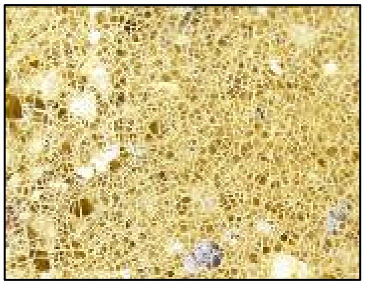


The Earth's Compressibility



Terrestrial pressure squeezing upward might explain underground rivers, but Da Vinci, to his credit, saw a problem.

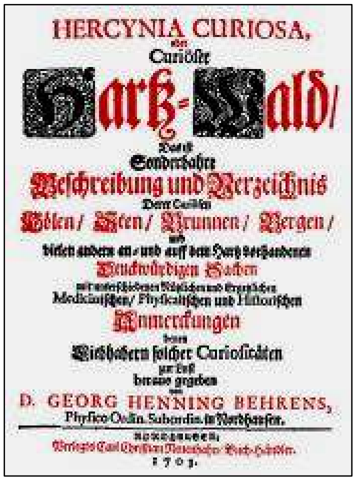
> *If you should say that the earth's action is like that of a sponge which when part of it is placed in water sucks up the water so that it passes up to the top of the sponge, it cannot then pour away any part of itself down from this top, unless it is squeezed by something else, whereas with the summits of the mountains one sees it is just the opposite, for there the water always flows away of its own accord without being squeezed by anything.*



Because his works were read extensively, Jerome Cardan (1501-1576) was influential during the latter 1500s. Although Cardanus plagiarized da Vinci, he seems to have preferred Aristotle regarding the origin of springs. The earth, like a sponge, is full of water always being squeezed free. As the proportion of land greatly exceeded that of water, water remains on the surface only because there is not enough room for it within.

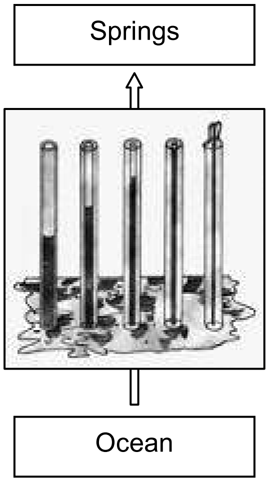
Again we have a subterranean machine defying principles of elementary physics -- whatever pressure might squeeze a sponge would keep it squeezed -- a fact recognized by Georg Henning Behrens in The Natural History of Hartz Forest, being a Succinct Account of the Caverns, Lakes, Springs, Rivers, ... in the Said Forest (1703).

> [Some say] *that the Earth sucks up the Water like a Sponge: but if that were true it should also swell like a Sponge; which is against Experience...*
>
> *For a Sponge affords no moisture till 'tis squeez'd.*



HERCYNIA CURIOSA,
oder
Curiöſer
Hartz-Wald/
Das iſt
Sonderbahre
Beſchreibung und Verzeichnis
Derer Curiöſen
Hölen/ Seen/ Brunnen/ Bergen/
und
vielen andern an- und auff dem Hartz vorhandenen
Denckwürdigen Sachen
mit unterſchiedenen Nützlichen und Ergetzlichen
Mediciniſchen/ Phyſicaliſchen und Hiſtoriſchen
Anmerckungen
denen
Liebhabern ſolcher Curioſitäten
zur Luſt
heraus gegeben
von
D. GEORG HENNING BEHRENS,
Phyſico Ordin. Subordin. in Nordhauſen.
NORDHAUSEN,
Verlegts Carl Chriſtian Neuenhahn/ Buch-Händler.
1703.

Capillary Action



Water's attraction to earth is known by all who garden. Perhaps rivers flow underground because the earth sucks it onward.

William Derham's (1657-1735) Physico-Theology (1713) declared that water rises from the level of the sea to the tops of mountains by capillary action. We'll see more of Derham in Chapter 13, Hydrotheology/Theohydrology, a chapter inspired by his work's title.

La Spectacle de la Nature (1732) by Noël-Antoine Pluche (1688-1761) was a work of eight volumes. From it,

> *The seawater deposits its salt on the sands below, and that it rises little by little, distilling through the sands, and the pores of the earth, which have such a power of attraction as it is not easily accounted for, and that not only sand, but other earthly bodies have the power of attracting water, I am well assured of from an observation which occurred to me but this vary day. When I threw a lump of sugar into a small dish of coffee, I found that the water immediately ascended through the sugar and lay upon the surface of it. Yesterday I observed likewise that some water which had been poured at the bottom of a heap of sand ascended to the middle of it. And this case, as I take it, is exactly the same with respect to the sea and the mountains.*

LE SPECTACLE
DE
LA NATURE.
TOME HUITIÈME,
Contenant ce qui regarde
L'HOMME EN SOCIÉTÉ
AVEC DIEU.
SECONDE PARTIE.

A FRANCFORT, *en Foire,*
Chez J. F. Bassompierre, Libraire, à Liège,
&
J. Vanden Berghen, Libraire, à Bruxelles.

M. DCC. LII.

A problem with the sugar-cube analogy is that landscapes are not made of sugar. The table below indicates typical heights of capillary rise in soils.

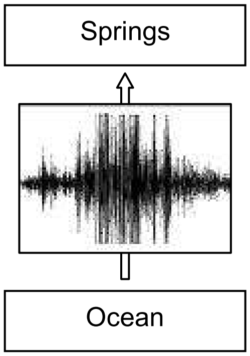
	Capillary Rise (m)
Fine Gravel	0.002
Very Coarse Sand	0.006
Coarse Sand	0.013
Medium Sand	0.025
Fine Sand	0.043
Silt	0.105
Fine Silt	0.200

Relative to the height of mountains, capillary rise is negligible.

A more fundamental mechanical problem lies in the fact that capillary action will not expel fluid from a conduit. If it could, we'd have a perpetual motion machine, albeit a small one. Pluche didn't check if the water ran out the top of his sugar cube and down the side.

An underground river can not be driven by the pull of the soil.

Earthquakes

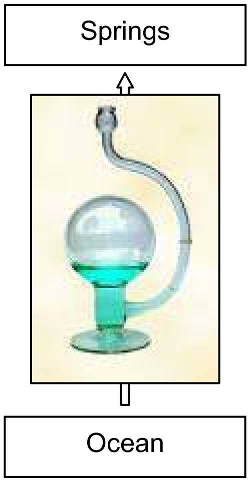


We can look to Thales (Chapter 2) for associations between earthquakes and springflow, but we'll again pick up the subject in the late 1400s. Da Vinci's evidence included,

> *That there are springs which suddenly break forth in earthquakes or other convulsions and suddenly fail; and this happened in a mountain in Savoy where certain forests sank in and left a very deep gap, and about four miles from here the earth opened itself like a gulf in the mountain, and threw out a sudden and immense flood of water which scoured the whole of a little valley of the tilled soil, vineyards and houses, and did the greatest mischief, wherever it overflowed.*

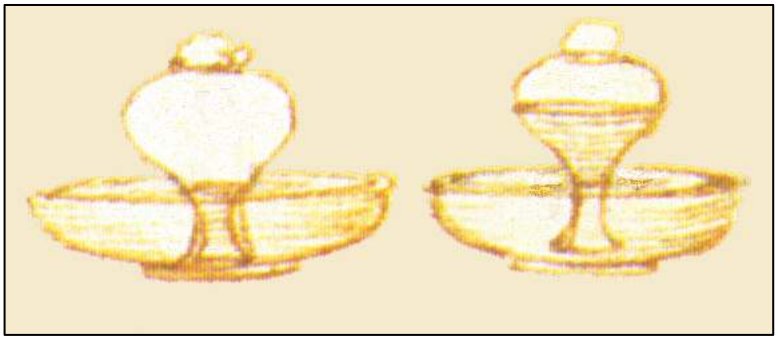
Unlike many of da Vinci's hydrologic claims, he would have had personal knowledge of the Alpine Savoy. No subterranean reservoir, there or anywhere, has ever been rent open by an earthquake, however. Were such reservoirs to exist and were tremors to rupture them, we'd still be pressed to explain springs that don't diminish over the long period.

Pneumatics



The atmosphere was also thought to motivate underground rivers, the role variously taken to come from the suction of wind, a vacuum produced by the outflow of springs, pressure on the land surface and/or pressure from enclosed cavities.

Da Vinci considered Heron of Alexandria's experiment in which a burning coal is placed in an inverted vessel inserted below a water surface. Water rises within the vessel.

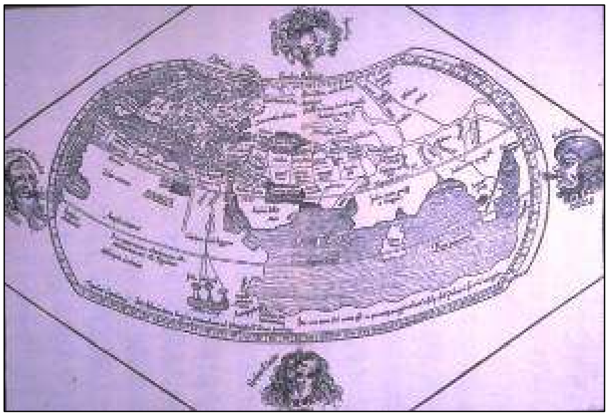


Da Vinci correctly attributed the phenomenon to the rarification of air within the receptacle -- as opposed to the direct action of the heat -- and was thus willing to reject the hypothesis in which the heat of the sun draws the water to the heights of mountains.

> *And if you should say as has been said that the sun sucks up and draws the waters from the roots of the mountains to their summits, then as the heat draws the moisture to itself the heat which is more powerful would draw to itself a greater amount of water than the less powerful. In summer therefore during the fiery heats the springs of the waters would have to rise higher into the summits of the mountains than they do in winter; but we see it is the contrary seeing that in summer the rivers lack a great part of their waters.*

Because rain clouds often appear in conjunction with wind gusts, da Vinci believed that a vacuum is formed by the condensation. Actually, it's the aerodynamic drag of falling droplets that draws air downward. Variation of atmospheric pressure indeed explains the paths of frontal rainstorms, but the same can't be said for the flow of liquid water.

Gregor Reisch (1467-1525) was an intellectual of the Humanist era. His chief work was the Margarita Philosophica (1504), an encyclopedia of knowledge for youthful students, the World Book of his day.

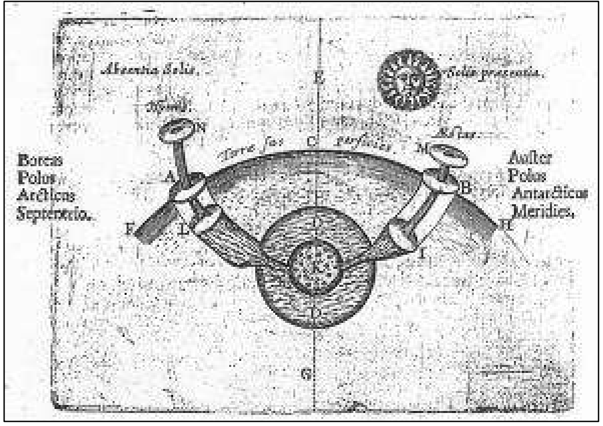


Following is his explanation of the role of pressure, or more specifically, negative pressure.

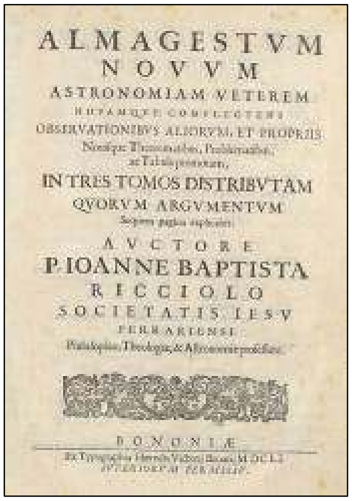
> *Within the earth as we have shown there are many open spaces and passages, into which (since there can be no such thing as a vacuum) vapors are drawn up from the earth and condensed into drops of water which unite to from rills, which running down to lower levels issue into the open air as springs.*

Reisch then went on to assert that the condensation results in a new vacuum which in turn draws up more vapor. In short, the water sucks itself up.

The plungers in the illustration from Fludd's Philosophia Mosaica (1638) suggest a pneumatic causation for subterranean flow, though in this case it seems to be at global scale.



A variant on the vapor-bootstrap theory was put forward by Giovanni Battista in Almagestum Novum (1651). Moisture rises within the earth as natural vapor from seawater that has seeped into the ground. Condensed by the cold of winter or at night, a vacuum ensues and seawater is drawn up to fill it. Rainfall could not provide an adequate supply for springs, as it penetrates no more than 4 or 5 meters into the earth; and the Bible records that springs were in existence before the first rainfall.



ALMAGESTVM
NOVVM
ASTRONOMIAM VETEREM
OBSERVATIONIBVS ALIORVM, ET PROPRIIS
IN TRES TOMOS DISTRIBVTAM
QVORVM ARGVMENTVM
AVCTORE
P. IOANNE BAPTISTA
RICCIOLO
SOCIETATIS IESV
FERRARIENSI
BONONIÆ

Kircher, never at a loss for explanations, also looked to air pressure. From his Mundus Subterraneus (1665),

> *The sea, by pressure of air and wind or movement of the tide pushes the waters through subterranean passages to the highest water chambers of the mountains.*

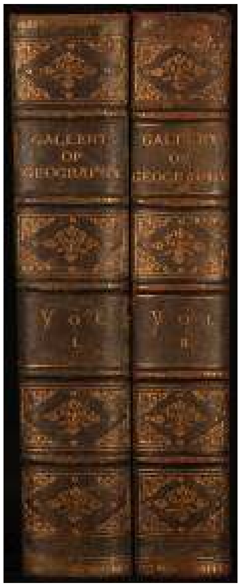
Readers of "The Artesian Well," Western Rural and American Stockman, February 22, 1894, were misinformed that some artesian wells are due to subterranean gasses.

> *The philosophy of the flow of water from artesian wells is generally known. No matter how deep in the earth the well may have been sunk to strike a subterranean vein or pool of water, one of two causes must operate to force a flow of water to the surface. One of these causes* [the sole correct one, we now know]*, and the most common, is the existence of a fountain or source of supply situated at a higher altitude than the point of discharge at the surface of the ground where the well is situated, and generally a long distance away. The other cause, as a whole or in part, is the expansive force of air and gases, which operating under the column of water to be forced to the surface, supplies the power needed to do the work which the gravity pressure from a distance and higher fountain head has failed to do.*

Nathaniel S. Shaler's discussion of artesian wells in Outlines of the Earth's History, A Popular Study in Physiography (1898) was a bit more complex.

> *It may be well to note the fact that the greater part of the so-called artesian wells, or borings which deliver water to a height above the surface, are not true artesian sources, in that they do not send up the water by the action of gravitation, but under the influence of gaseous pressure... In all cases this water contains a certain amount of gases derived from the decomposition of various substances, but principally from the alteration of iron pyrite, which affords sulphuretted hydrogen. Thus the water is forced to the surface with considerable energy, and the well is often named artesian, though it flows by gas pressure on the principle of the soda-water fountain.*

Thomas Milner's The Gallery of Nature, A Pictorial and Descriptive Tour Through Creation, Illustration of the Wonders of Astronomy, Physical Geography, and Geology (1882) provides some pneumatic speculation.



> *Weeding Well, in the Peak of Derbyshire, other wise called the Ebbing and Flowing ... lies in a field by the road-side in the neighborhood of Castleton Dale, surrounded with mud and weeds. The motion of the water depends upon the quantity of rain during the season, and is by no means regular, as it has ceased to flow for several weeks during a drought; but, in very wet weather, it will flow and ebb more than once in an hour. The time which it continues to flow varies; but it is sometimes four or five minutes, the water appearing at first slightly agitated, and then issuing forth from nine small apertures with a gurgling sound. After remaining stationary, it then ebbs to its ordinary level... No theory has yet been proposed to account for the peculiarity of these springs which is perfectly satisfactory; but probably the interposition of columns of gas conveying pressure, somewhat on the principle of Hero's fountain, acts an important part, as well as the common hypothesis of an interior cavity of water discharging itself by a siphon-formed channel.*

A pneumatic engine for underground rivers requires a disparity in air pressure to push or suck water uphill. And indeed the atmospheric pressure at the foot of a hill is greater than that at the top, but the difference in energy (what would propel the fluid) is nil because the pressure drop is balanced by the elevation gain.

And 25 years later, the pneumatic theory with two options: one due to atmospheric pressure differential and the other to vapor entrainment. From "Blowing Springs and Wells of Georgia, with an Explanation of the Phenomena," Science, February 8, 1907, by S.W. McCallie,

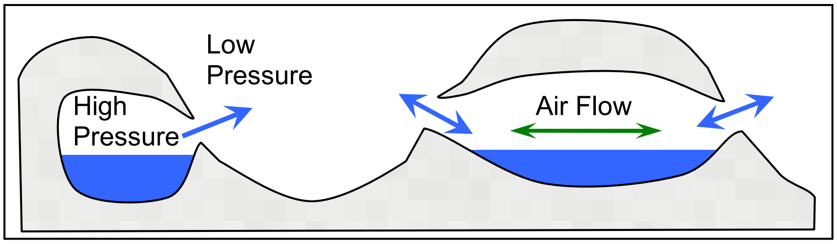
> *Grant Blowing Spring*
>
> *The phenomenon can readily be detected by holding a smoldering match or lighted paper near the opening from which the water flows. The motion of the air is to be seen in its full force at an opening in the bluff above... At this opening, which leads down to the stream supplying the spring, there is, at times, a strong current of air passing inward or outward, depending on the atmospheric conditions hereafter to be discussed.*
>
> *Boston Well*
>
> *The Boston deep well belongs to the second class of blowing wells, namely, wells in which the direction of the air current is in one direction only.*
>
> *The main water supply at present is said to come from a subterranean stream in the limestone at 120 feet... Shortly after the completion of the well, Mr. J.Z. Brantley, the mayor of the town, discovered that there was a continuous draught of air passing down the casing, and by placing his ear near the mouth of the well he was able to detect a sound like running water. This indraught, Mr. Brantley reports, was quite strong and continued as long as the well was left open.*
>
> *The Lester Well*
>
> *Mr. Miller, in describing this well, says that at a depth of 154 feet he struck a stream of water running so swiftly that he could not pass a two-pound iron plumb bob attached to a fishing line through it. He reports blowing crevices in the well at 87, 124 and 144 feet. When the well was being bored the air from each of these cavities is said to have passed in in the forenoon and out in the afternoon; but after the completion of the well to the swift moving subterranean stream, the air ceased to pass outward, but was sucked in with a strong steady pull, drawing the flame and smoke of a torch down the casing when held 6 inches above its opening.*

> *Causes of Blowing Springs and Wells.*
>
> *The two classes of blowing springs and wells above described appear to be due to two entirely different causes. Those of the first class, of which the Grant Blowing Spring is a good type, seem to be due entirely to the difference of atmospheric pressure of the air on the outside and on the inside of the cave.*

It's the pneumatic subterranean engine, the earth's interior air pressure blowing out the water.

> *In the second class of wells and springs, the constantly outgoing or the constantly ingoing current is entirely independent of atmospheric conditions. The currents, whether outward or inward, act with equal energy during high or low barometer and always move in the same direction. The Boston and the Lester deep wells are excellent examples of wells and springs of this class. The phenomenon which they exhibit seems to be due entirely to the friction of the air on a rapidly moving current of water. This phenomenon is beautifully illustrated in Richard's water air-blast, to be found in many well-equipped chemical laboratories. In the Boston well, and also in the Lester well, appear almost exactly the same conditions met with in Richard's water air blast. The well itself forms the inlet for the air, and the rapidly flowing stream in the subterranean channel below completes the conditions necessary for an ingoing air blast... It naturally follows that it must escape at some other point as an outgoing current, thus giving rise to continuously blowing caves or springs. As underground streams frequently pass from one bed of rock to another in their subterranean course, they, no doubt, often form waterfalls which possess all the essential conditions necessary for producing an air blast, thus giving rise to continuously blowing caves and springs.*

The two classes of blowing wells and springs



McCallie provided additional explanation in A Preliminary Report on the Underground Waters of Georgia (1908).

> *It will be seen by the description of the Quitman deep well that not all deep wells penetrating subterranean channels with swift flowing streams are blowing or sucking wells. This may be accounted for by the channel being only partially filled with water, and the air being able to circulate freely within. The essential condition of continuous suction in wells is that the air once dragged into the underground stream by the friction of the water cannot again reach the point of intake.*
>
> *The current of air above noted at the entrance of the cavers at Forest Falls is also due to the friction of the air and water, but as the air is free to escape into a subterranean chamber and the accompanying air could not escape by the way of its entrance it would give rise to a strong blast. As underground streams frequently pass from one bed of rock to another in their subterranean course, they no doubt often form waterfalls which possess all of the essential conditions necessary for producing air an blast and thus give rise to continuously flowing caves or springs,*

McCallie's pneumatic theory wasn't confined to scientific publication, as evidenced in the Bend [Oregon] Bulletin, March 30, 1906

> *Drafts over deep wells are usually due to changes of temperature or barometric pressure, air being forced in as the pressure rises and drawn out when the barometer is falling. But in tow wells in the Vicksburg Jackson limestone of southern Georgia have shown the strange phenomenon of a continuous in-draft. This has been investigated by S.W. McCallie, who has*

> *found a rapid subterranean stream at a depth of about 120 feet, and it is supposed that the air is sucked in by friction and carried along until the water rises as a large spring.*

McCallie's logic is circular, of course, the water dragging the air and the air powering the water, but then again, understandings that seem logical to us may well be dismantled in the century to come.

Richard's apparatus made use of the injector principal to supply relatively small volumes of compressed air at low pressure. A small jet of water projected through a tube of gradually increasing diameter sweeps a larger volume of air into a receiver where the two are separated. Efficiency is increased by a projecting step in the injector tube, or by giving the tube the form or an undulating curve, deflecting the jet to completely fill the passage.

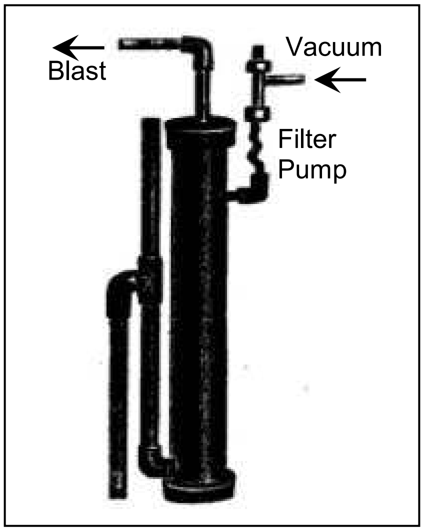
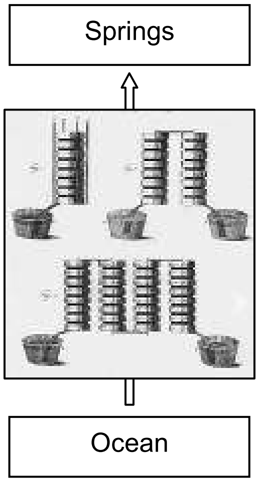


Illustration from Laboratory Supplies and Chemicals for Chemists and Bacteriologists (1919), A. Daigger & Company

Electromagnetism



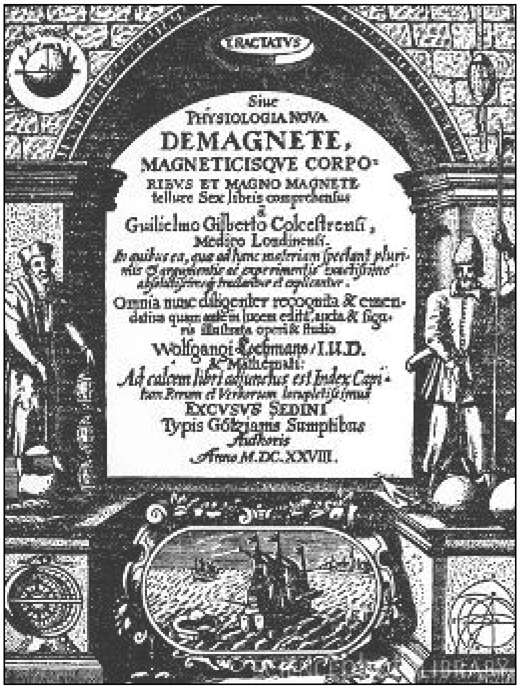
We'll pursue the modern understanding of geomagnetism in Chapter 45, but here we can note what's been widely understood for centuries, that our globe has magnetic properties.

A relationship -- or lack thereof, we may come to conclude -- between underground rivers and electromagnetism might be manifested in one of three manners.

As an electromagnetic field emitted by subterranean waters revealing the water's presence, a hypothesis we'll consider in Chapter 46, Finding the Underground Waters.

As an electromagnetic field emitted by subterranean waters altering our terrestrial environment, allegations we'll weigh in Chapter 87, The Paranormal.

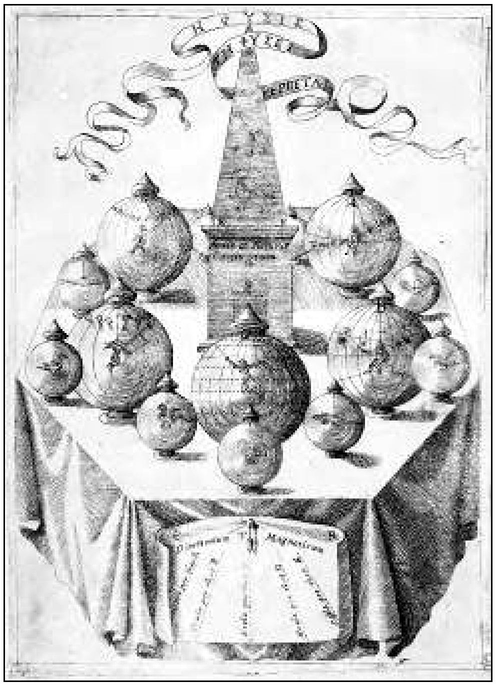
As an electromagnetic engine for the propulsion of subterranean water. With discovery of a relationship between magnetism and electricity -- what we now know to be an electromagnetic field -- it is not surprising that early investigators hoped that this new science might resolve geophysical perplexities, how water seemed to rise to mountain tops, for example.



TRACTATVS

Siue
PHYSIOLOGIA NOVA
DE MAGNETE,
MAGNETICISQVE CORPORIBVS ET MAGNO MAGNETE
tellure Sex libris comprehenſus
à
Guilielmo Gilberto Colceſtrenſi,
Medico Londinenſi.
In quibus ea, quæ ad hanc materiam ſpectant pluri-
mis & argumentis et experimentis exactiſſime
abſolutiſſimeq; tractantur et explicantur.
Omnia nunc diligenter recognita & emen-
datius quam antè in lucem edita, aucta & figu-
ris illuſtrata operâ & ſtudio
Wolfgangi Lochmans, I.U.D.
& Mathematici.
Ad calcem libri adjunctus est Index Capi-
tum Rerum et Verborum locupletiſſimus
EXCVSVS SEDINI
Typis Götzianis Sumptibus
Authoris
Anno M.DC.XXVIII.

De Magnete (1600) by William Gilbert (1544-1603). In the first work to describe the earth's magnetic field, oceanic tides stem from magnetic interaction between earth and moon.



"Magnétisme et hydromantie" from Kircher's Magnes Sive de Arte Magnetica Opus Tripartitum (1643) which considered the magnetism of the earth and heavenly bodies, the tides and the metaphorical position of God, “the central magnet of the universe.”

Presented in the Epitome of Copernican Astronomy (1618-1621), the natural philosophy of Johannes Kepler (1571-1630) -- whom we noted in Chapter 8 for his chemical speculations -- added a solar magnet to Gilbert's electrical universe.

> *The conclusion is therefore plausible: because the Earth moves the Moon by its species, and is a magnetic body; and because the sun moves the planets in a similar manner by the species which it emits, therefore the Sun, too, is a magnetic body.*

Kepler was in fact close to the modern idea of gravity.

> *If the moon and earth were not retained in their respective orbits by an animal force or by some equivalent force, the earth would climb toward the moon and the moon would descend toward the earth until these two heavenly bodies were joined. If the earth ceased attracting the waters covering it, the sea waves would all rise and flow toward the body of the moon.*

EPITOME
ASTRONOMIÆ
COPERNICANÆ
Uſitatâ formâ Quæſtionum & Reſponſionum conſcripta, inque VII. Libros digeſta, quorum
TRES hi priores ſunt
De
Doctrina Sphærica.
HABES, AMICE LECTOR, HAC PRIMA parte, præter phyſicam accuratam explicationem Motus Terræ diurni, ortusq; ex eo circulorum Sphæræ, totam doctrinam Sphæricam nova & concinniori METHODO, auctiorem, additis Exemplis omnis generis Computationum Aſtronomicarum & Geographicarum, quæ integrarum præceptionum vim ſunt complexa.
AUTHORE
IOANNE KEPLERO IMP.
[illegible]
Cum Privilegio Cæſareo ad Annos XV.
FRANCOFVRTI,
Impenſis Ioannis Godefridi Schönwetteri
Excudebat Iohan. Fridericus Weiſſius.
ANNO M DC XXXV.

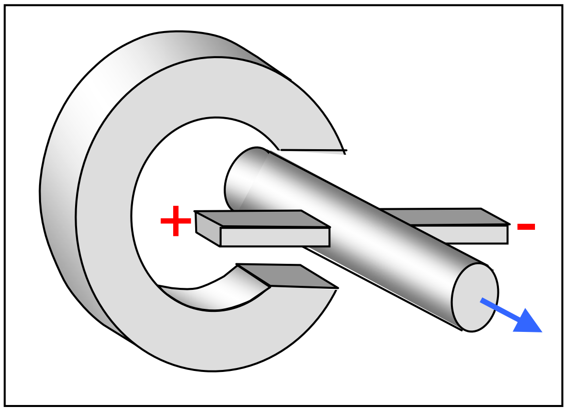
While earth science soon abandoned a magnetically-driven hydrologic cycle, the possibility of magnetically-assisted water flow is yet discussed.

Laplace's Law describes the interaction between a magnetic field and an electric current when they are applied at right angles to each other and to a conductor of electricity. When an electrical current is passed through the conductor, an electromagnetic force known as a Lorentz force pushes the conductor in a direction perpendicular to the conductor and the magnetic field. The magnitude of the force is proportional to the magnetic field strength and the current density.

We will consider four schemes for an electromagnetic engine suitable for elevating a fluid.

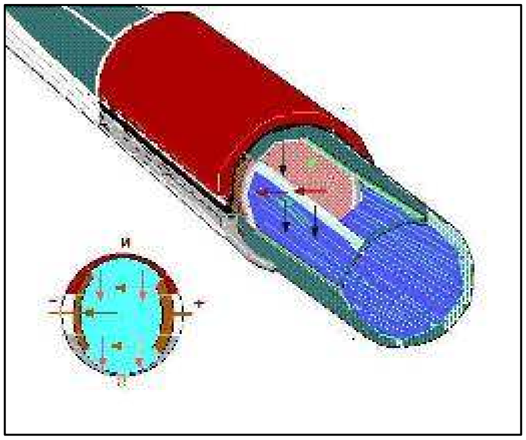
Method 1. Liquid Metal Pump

An electromagnetic pump moves liquid metal through a pipe between the poles of an electromagnet by passing a current through the liquid metal. To the tight is the conceptual design: a C-shaped permanent magnet, a pipe carrying molten metal as the conductor, and a direct current applied by an external source such as a battery.



Such a device can propel liquid metals, but not water?

Method 2. Water Pump



The Encyclopedia of Free Energy, a perpetual-motion reference, hypothesizes a like-comprised electromagnetic pump in which "there is no moving core except the motion of the liquid salty water," failing to recognize that the "liquid salty water" must be magnetized, a quality not within water's capacity because its dipolarity is electrical, not magnetic.

Water's polarity is due to the higher nuclear charge of oxygen displacing the shared bonding electrons towards the nucleus, leaving the oxygen with a partial negative charge and the hydrogen with a partial positive charge.

For a molecule to become magnetized, it must not only contain an unpaired electron, but also must group with like-aligned molecule into local domains that amplify the effect and retain their orientation over time. The effect is known as "ferromagnetism," the most well known example, of course, being metallic iron.

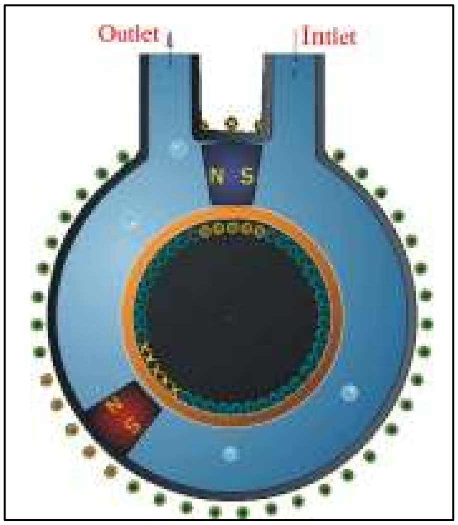
To the Encyclopedia of Free Energy's credit, there is the disclaimer attached to its plans involving PVC pipe and a windshield wiper motor: "Please remember this only an Experimental Idea."

Electrical dipolarity gives water the ability dissolve, at least in small part, most geospheric inorganic solids, making water the "universal solvent," a quality of consequence in Chapter 39, Karstology.

Method 3. Levitation

Being electrically dipolar, a stream of water can be directed by an electromagnetic field, the static electricity a hair comb providing an easy experiment.

A water molecule can in fact be levitated by an electromagnetic field roughly 300 times that of the earth's, doable with electromagnets, but not with permanent magnets. No one has pulled water up a well tube or even above a lab table.



Method 4. Reciprocating Pump

Another, and very different, electomagnetic pump concept employs two rotating magnets in an annular channel, simultaneous energized with opposing polarity by of a pair of solenoids. One magnet works as a pump while the other is between the inlet and the outlet ports, acting as a valve. With each cycle, the magnets reverse their function. Tests have yielded a flow rate of 13.7 milliliters/minute at 200 rpm at a pressure of 785 Pascals, something less than 1 percent of atmospheric pressure.

This pump is thus just a mechanical pump in which magnetic switches control the component function.

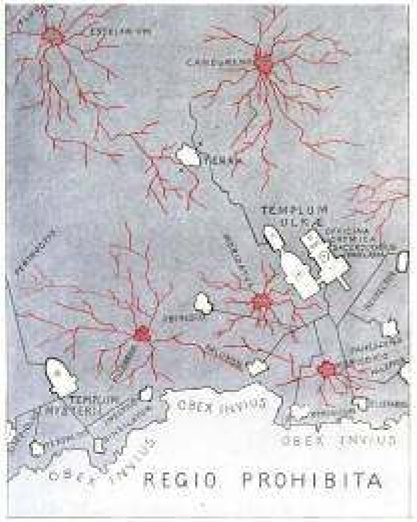
Method 1 can work, but not for water.
Method 2 does not work.
Method 3 can work, but not at hydrologic scale.
Method 4 is a novel rotational pump utilizing electrical, rather than mechanical, switches.

While the concept of an electromagnetic engine for subterranean streamflow resonates with some aspects of modern geoscience and technology, it's a proposition that again and again fails upon further consideration.

In 1940, M. King Hubbert's The Theory of Ground Water Motion demonstrated that Darcy's equation for groundwater (Chapter 43) is analogous to Ohm's law for electric current. By no means, however, does this imply that subsurface water is driven by electricity, but rather that the mathematical form of the underlying equations are the same. Because things act the same is not to say that they are the same.

We'll turn to literary fiction in chapters ahead, but the setting of John Mastin's The Immortal Light, a Scientific Romance (1907), an underground world in which electrical charge is the driver of nature, provides a fitting departure for our consideration of electromagnetism as a hydrologic energizer.

> *The air seemed to come along with several swiftly-flowing underground streams which roared and swelled in cataracts of foam... All this part was palisaded round, and well for us it was so protected, as the effect of the seething mass of foam-covered water had a curious, hypnotic effect on us, as it ran eddying in countless circles, all running to the outlet.*
>
> *Some distance farther on it was even more inviting, for the cotton wool became detached into little pillows which twisted and twirled in a most fascinating manner. These passed on so slowly that we could easily keep pace with them as we walked along the bank, and then, suddenly they shot like lightning over the mass of smooth, oily-looking water, and in a second, were split up again into a dust of foam.*



Underground river map

Our intrepid explorers, not evolved for their battery-like environment, must be wary of becoming short circuits.

> *"How do you account for the fact that this water is not magnetic?" asked Belt, after putting in his hands and feeling no shock. "Water is such an excellent conductor that it should carry the current from the other side of the wall. See, it flows from the inside."*
>
> *"So it would," replied Norris, "if it came here through an archway, or grating j but it seems to soak through the wall like water through carbon in a filter, thus the wall perhaps also insulates the water and makes it safe."*
>
> *This seemed to be the only explanation possible.*

Conclusion

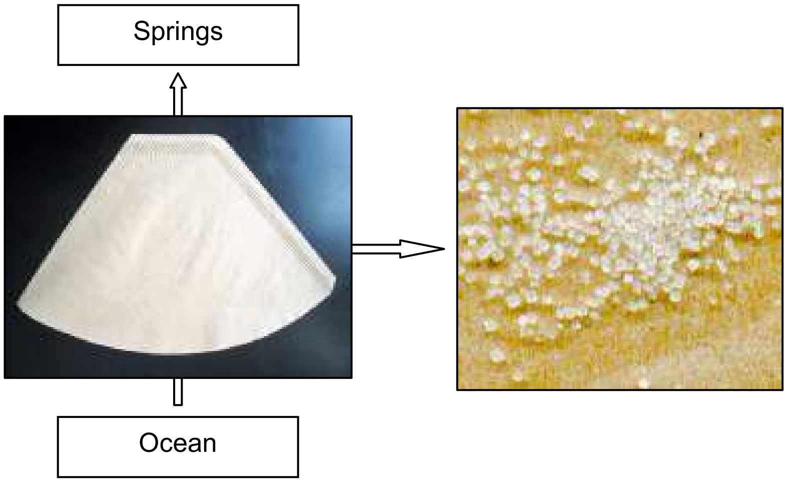
This and the previous two chapters suggest a myriad of engines thought possible to elevate subterranean rivers. Da Vinci hypothesized many such mechanisms, Kircher provided striking graphics and any number of early scientists proposed theoretical bases for such hydrologic pathways. As we will pursue in chapters to come, such speculation even today enlivens popular fantasy.

CHAPTER 11

STRAINING THE SALT

As to the source of the sea's salinity, the early philosophers were accord -- the sea is the "sweat of the earth." In this, they were correct.

As to the freshness of streamflow, the thinkers were likewise in agreement -- the earth filters away the salt. It this, they were wrong.



Why is the Sea Salty?

The Greeks of Chapter 2 were familiar with two processes thought to remove salt from water.

Evaporation, solar or by fire, could be seen to leave salt crystals behind.

Filtration through a cloth or fine-grained media could likewise be seen to leave residue. That the residue was coarse particulates, not salt grains, wasn't taken to be significant.

We know today that dissolved salts are filterable only by energy-consumptive reverse osmosis, a technology of recent decades and requiring human operation. While we're no more intelligent than the Greeks, we've the advantage of textbooks in physical chemistry.

Anaximander (611-547 BC) believed that all the earth was initially surrounded with moisture which dried into seas, which too, would ultimately expire.

To explain freshwater springs, Heraclitus (540-475 BC) cited distillation and filtration in the atmospheric and subterrestrial routes, respectively.

Anaxagoras (500-428 BC) attributed the sea's salinity to what the water gathers as it runs over the earth, akin to how water strained through ashes becoming salty. The sea is the accumulation of such runoff. To this point, the Greek is entirely correct, but now his thinking becomes muddled. Assuming only a subterranean hydrologic cycle, the sea’s salinity is augmented by its underground descent in which it garners a portion of the matrix through which it passes. Evaporation concentrates the substrate, expelling the supernatant.

Empedocles (490-430 BC), a founder of the cosmogenic theory of the four classical elements, left us a poetic definition of seawater as "the sweat of the earth." It says it all.

Democritus (460-370 BC) held that the salinity of the sea is due to the same cause as the accumulation of salt on the land, like seeking like. As the water flees via secret channels to lakes and rivers, the sea will become smaller and smaller and finally dry up.

Aristotle (384-322 BC) drew upon them all.

> *At first the Earth was surrounded by moisture. Then the sun began to dry it up, part of it evaporated, and is the cause of winds while the remainder formed the seas. So the seas are being dried up. Others say that the sea is a kind of sweat exuded by the earth when the sun heats it, and that this explains its saltness, for all sweat is salt. Others say that the saltness is due to the earth. Just as water strained through ashes becomes salt, so the sea owes its saltness to the mixture of earth with similar properties.*
>
> *The fresh water, then, is evaporated, the salt water left. The process is analogous to the digestion of liquid food. The place occupied by the sea is the natural place of water, and fresh water evaporates more easily and quickly when it reaches and is dispersed in the sea. The sea is not salt either because it is a residue left by evaporation or because of an admixture of earth; nor is it any explanation to call it the sweat of the earth.*

Concluding "nor is it any explanation to call it the sweat of the earth" seems odd from a biologically-inclined philosopher, but to Aristotle's credit, his was the first theory of salt circulation not reliant on subsurface filtration.

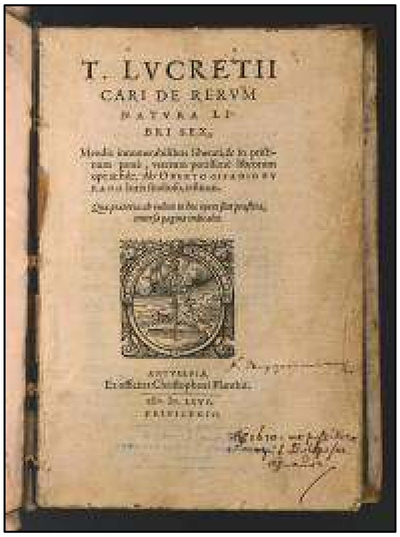
Seneca (3 BC-65 AD) agreed with the early Greeks that marine substances separate. Re-quoting from Chapter 3,

> *The sea water returns by a secret path, and is filtered in its passage back. Being dashed about as it passes through the endless, winding channels in the ground, it loses its salinity, and, purged of its bitterness in such a variety of ground as it passes through, it eventually changes into pure, fresh water.*

Unlike his predecessors, however, Seneca was on the lookout for evidence. "The endless, winding channels in the ground" he believed to be proven by calcareous tuff.

The poet Lucretius Caro (99-55 BC) adopted Aristotelian explanations in De Rerum Natura. Mt. Etna, Lucretius suggested, is hollow. As for the source of springs,

> *The sun drinks some, to quench his natural heat;*
> *And some the winds brush of.*
> *Some passes through the earth, diffused all over,*
> *And leaves its salt behind in every pore;*
> *For all returns through narrow channels freed*
> *And joins where ere fountain shows her head*
> *And thence fine streams in fair meadows play.*



T. LVCRETII
CARI DE RERVM
NATVRA LI-
BRI SEX,

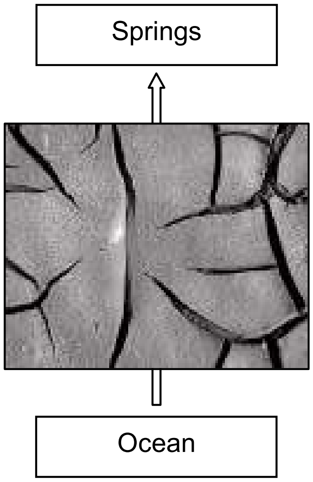
"The clouds imbibe much seawater," as some translations render the leading words. The power of wind drives together an abundance of clouds and presses the water out.

"And leaves its salt behind in every pore" was an insightful consequence for a Roman poet, but one not to be carried to logical conclusion until much later.

Less astutely, Lucretius noted,

> *Since the earth has a porous body, and it is joined together with the sea, girdling its shores all around, it is necessary that as the flow of water comes from the land into the sea, so also it should ooze into the land from the salt sea; for the pungency is strained off, and the substance of the water oozes back, and all meets in a moving mass of sweet along the path which was once been cut for it in its liquid course.*

The science is Roman -- to put it positively -- but as "ooze into the land" is poetic, we'll grant a schematic of squeezed mud.



Fifteen centuries later, even Athanasius Kircher (1602-1680), whom we met in Chapter 8, never shy with answers, was perplexed by the oceans. According to Bishop Richard Watson's Chemical Essays (1781-1787),

> *Father Kircher, after having consulted three and thirty authors upon the subject, could not help remarking, that the fluctuations of the ocean itself were scarcely more various then opinions of men concerning the origin of its saline impregnation.*

But Why, Then, are Springs Not?

We need only consult Aristotle.

As fresh water is lighter than saltwater, the former properly seeks its natural place above the latter by rising, though the philosopher himself wouldn't have defined "lightness" in terms of physical measurement. That dissolved salt doesn't settle within the liquid, leaving a fresh upper stratum, was pragmatically recognized by the Greeks, but Aristotle and his followers wouldn't have conditioned the voracity of philosophical truth on fallible physical verification. Fresh seeking fresh and salt seeking salt, the philosopher would have determined.

The practicality of subterranean salt separation aside, any desalination scheme poses a consequent question. What becomes of the residue?

In the short run, we might expect the formation of salt beds, a geological formation familiar to the ancients. In the long run, however, there's only so much subterranean space to store the byproduct.

In his Notebook entry "Refutation of the Pliny's Theory of the Saltness of the Sea," da Vinci (1452-1519) ponders Pliny. We'll break da Vinci's thoughts into proposition and refutation.

Pliny says that the water of the sea is salt because the heat of the sun dries up the moisture and drinks it up; and this gives to the wide stretching sea the savor of salt.	*But this cannot be admitted, because if the saltness of the sea were caused by the heat of the sun, there can be no doubt that lakes, pools and marshes would be so much the more salt, as their waters have less motion and are of less depth; but experience shows us, on the contrary, that these lakes have their waters quite free from salt.*
Again it is stated by Pliny that this saltness might originate, because all the sweet and subtle portions which the heat attracts easily being taken away, the more bitter and coarser part will remain, and thus the water on the surface is fresher than at the bottom.	*But this is contradicted by the same reason given above.*
Again, it has been said that the saltness of the sea is the sweat of the earth.	*To this it may be answered that all the springs of water which penetrate through the earth, would then be salt.*
But the conclusion is, that the saltness of the sea must proceed from the many springs of water which, as they penetrate into the earth, find mines of salt and these they dissolve in part, and carry with them to the ocean and the other seas, whence the clouds, the begetters of rivers, never carry it up	*And the sea would be saltier in our times than ever it was at any time.*
And if the adversary were to say that in infinite time the sea would dry up or congeal into salt,	*To this I answer that this salt is restored to the earth by the setting free of that part of the earth which rises out of the sea with the salt it has acquired, and the rivers return it to the earth under the sea.*

We tend to know da Vinci for his intuition, not his formal logic, but here he lays bare the consequential fallacy of two millennia of natural philosophy. The earth beneath us has not over the eons become an accumulation of salt.

Geological action lifts up the salty sea bed and rivers, both above and below ground, return it to the sea. But as was his journaling propensity, da Vinci rarely halted when he was ahead.

> *The ocean does not penetrate under the earth, and this we learn from the many and various springs of fresh water which, in many parts of the ocean make their way up from the bottom to the surface. The same thing is farther proved by wells dug beyond the distance of a mile from the said ocean, which fill with fresh water; and this happens because the fresh water is lighter than salt water and consequently more penetrating.*
>
> *That fresh water penetrates more against salt water, than salt water against fresh is proved by a thin cloth dry and old, hanging with the two opposite ends equally low in the two different waters, the surfaces of which are at an equal level; and it will then be seen how much higher the fresh water will rise in this piece of linen than the salt; by so much is the fresh lighter than the salt.*

Fresh water does indeed float above saline water (a Ghyben-Herzberg lens to hydrogeologists), but it's due to a difference in density, not as a result of being "more penetrating." The fresh water's not lifted; it's seepage from above.

Da Vinci's reference to linen would seem to imply capillarity, but in that respect, fresh and saltwater are indistinguishable.

"The ocean does not penetrate under the earth" substantially contradicts da Vinci's writings of Chapters 7 and 8 in support of underground rivers. While da Vinci's critique of Pliny is sound, his own thoughts meandered.

Da Vinci's contempory, Felix Faber (1441-1502) drew attention to the connection between water sinking in mountain dolines and springs in the valleys below. From Faber's Historiae Suevorum (1489),

> *Therefore Nature has ready in the earth certain hollows in which the waters collect and... from whence they flow further through veins to the place where they have to flow out. These are especially noticeable in the Swabian Alps,, where one sees many cup-shaped pits in the ground, into which the rain and the snow water penetrate and sink into underground lakes from whence it gushes forth again*.

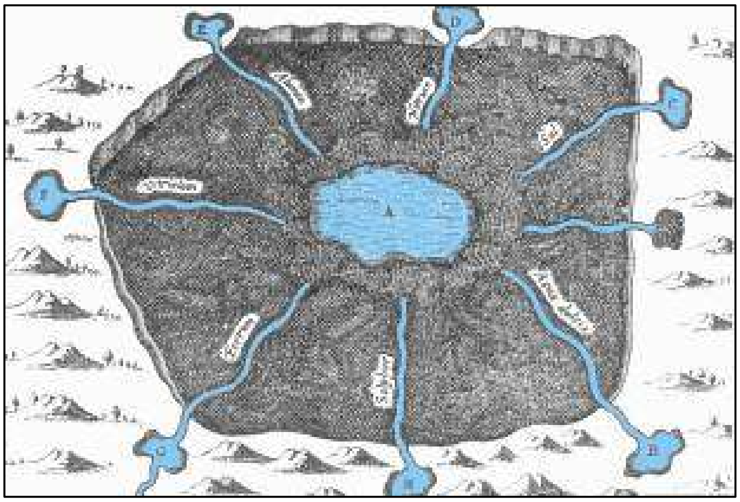
At the same time, however, he thought some springs also fed with desalinated sea water.

> *Incapable of bearing the severity of the sea, it* [spring water] *comes concealed in the veins of the earth and penetrates in inexplorable routes into the narrowest crevices of the earth and rock, so that it leaves behind it the bitter skin with which it was clad in the sea, behind on the sand, the rocks and the earth. And thus it eventually comes again to the place, from whence it started, and emerges sweet, clear and drinkable out of the earth, to flow again according to the word of the Preacher* [i.e., Ecclesiastes].

Meteorologicum (1627) by S.L. Fromondus dealt with springs, rivers, the sea and earthquakes. Seawater is evaporated by the earth's central fire, the salt coming off with "the steam and only being separated from it as it filters up through the earth."

Descartes expressed similar views in his Philosophidae Principia (1644), but being more widely read, hence had greater influence. The earth's heat causes steam to rise continuously from large seawater-filled cavities beneath the mountains, passing through crevices so minute that when the steam condenses against the cooler rocks, the condensate cannot return by the same route and therefore seeks larger fissures leading springs on the earth's surface. The salt left behind explains the deposits of rock salt.

Mathematician Jacques Pelletier (1517-1582) supposed that springs must be of marine origin, as many of them contain salt. While saline springs do exist, they're in fact uncommon, and thus here we have a logical determination based on false premise.



According to Kircher, the earth contains subterranean conduits from deposits of Ferrum, Sulphur, Aqua dulcis, Sal, Nitrum, Alumen and Vitriolum, all but the last easily cognated. "Vitriolum" is glass.

Pelletier overestimated the extent of saline springs and Kircher was far too fond of subterranean rivers, but the two scientists were on the chemical track. Mineral content indeed reveals the nature of a spring's source.

"Must Clog and Obstruct"

But let us return to Lucretius' earlier deduction that any ocean-derived subsurface stream that emerges as fresh water "leaves its salt behind in every pore."

Charles Hutton, whom we'll again encounter in Chapter 12, Superterranean Metrics, raised an irrefutable challenge in A Mathematical and Philosophical Dictionary, Containing an Explanation of the Terms, and an Account of the Several Subjects (1795).

> *And though the sand and earth through which the water ascends may acquire some saline particles from it, they are nevertheless incapable of rendering it so fresh as the water of our fountains is generally found to be. Not to add, that in process of time the saline particles of which the water is deprived, either by subterranean distillation or filtration, must clog and obstruct those canals and alembics.*

Natural desalination can't persist if the salt is left to smother the mechanism. Were underground rivers to work this way, the earth beneath our feet would by now be packed with white crystals.

Had the likes of Pelletier and Kircher pondered the implications of "clog and obstruct," their belief underground rivers might have been less certain. But as often the case through history, models rooted in culture are slow to fade.

Thomas Milner (Chapter 10) illustrated that even another century was not suffice for the demise of an illogical concept.

> *It is possibly the case, indeed, that the ocean filtering through pores of the earth the salt particles being lost in the passage may give rise to many springs; but as the preceding cause is amply sufficient to explain their formation, we need not recur to any other.*

As with all the candidate mechanisms of Chapter 8-8.2, salinity comes up short as the engine for underground streamflow.

Naturalists must have come to wonder why their otherwise-so-productive scientific method again and again failed to discover the mechanism for desalinating underground rivers. Perhaps -- we can imagine them at this point lowering their voices as to not invite the scorn of their colleagues -- the cause is absent because such rivers are not in existence.

We'll return to the subject of salt in Chapter 66, Minewaters.

CHAPTER 12

SUPERTERRANEAN METRICS

With Aristotle's help, Greek mythology sustained popular belief in underground rivers for millennia. Christianity then assumed the conceptual stewardship of underground rivers as the will of God. With Renaissance probing for sensible reason came a spectrum of candidate causalities for subsurface streams. Does the water rise because of a fiery earth? Tidal action? IChapters 8-10 provided more explanations than perhaps we can remember.

While scholasticism had moved beyond Plato to embrace observation, the Renaissance, per se, provided few tools by which to test the best explanations. Da Vinci wrote prolifically and drew exquisitely, but didn't bother with measurement.

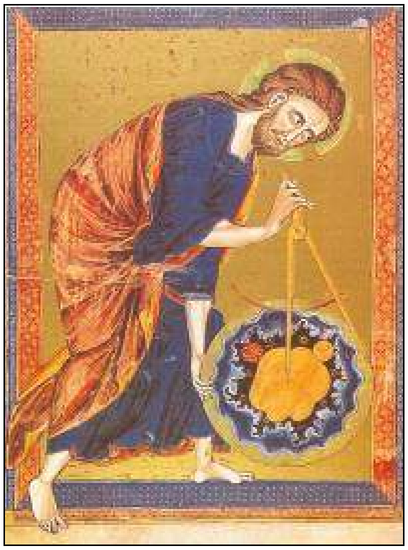
Until the era of Isaac Newton (1642-1727), five erroneous hydrological propositions were yet favored by most natural philosophers.

1. Mechanisms such as wind, capillary action wave or action can draw large quantities of water from the earth's interior.
2. Sea water can lose its salt by infiltrating through soil.
3. Rainfall is insufficient to account for all water discharged by rivers.
4. Rainfall can not infiltrate into the ground in large quantities.
5. The earth contains a large network of caverns and rivers.

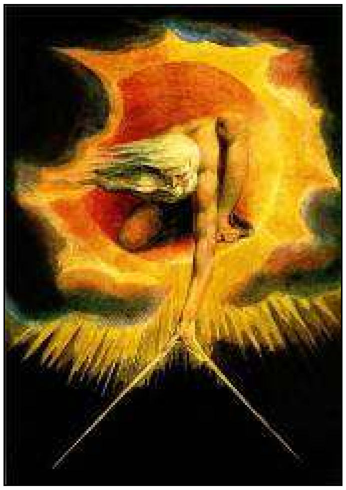
But combining Platonic credence in mathematics with an Aristotelian influx of physical evidence, hydrology was about to change.

The discernment process began to advance when chemist Robert Boyle (1627-1691) established the standard of experimental inquiry that's still with us: tests must be conducted under controlled conditions and observations must be replicable.

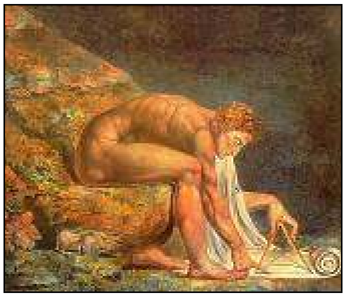
As illustrated by the three paintings below, metrics became valued.



God as Architect, from the Bible Moralisée, Codex Vindobonensis (c. 1250)



William Blake, God as an Architect (1794)



William Blake, Newton (1795)

In the leftmost piece, a product of the Middle Ages, God is measuring his creation, the units perhaps being metrics of holiness. In the next painting, 500 years later, God again reaches downward, but this time to measure the tangible. In the third, fueling the science vs. religion controversies to come, God is replaced by Newton.

Newton's Principia (1687) was elegant as it pertained to celestial workings, but provided little but a few conceptual pointers regarding much of what occurs below. The path of Mars made more mathematical sense than did the level of the Thames.

A 1692 issue of The Gentleman's Journal listed ten different explanations of the oceanic tides, complaining that competing ideas caused "the learned ... [to be] much puzzled about... the Flux and Reflux of the Sea."

The task of quantifying subsurface flow was indeed the most challenging part of the hydrologic cycle. Rainfall could be measured with a pan. Streamflow would be estimated by measuring a cross-section and timing a floating object. But no one could reach into the earth with a pan, a ruler, a clock, or for that matter, any instrument of measurement.

As we remarked in concluding Chapter 2, we'd like someone underground to take a look, but if we can't send someone with a lantern, perhaps we can measure what's occurring on the earth's surface and deduce the rest.

This chapter explores how measurement disproved the hydrologic necessity of underground rivers.

We'll begin by looking three Frenchmen,

Bernard Palissy,
Pierre Perrault and
Edmé Mariotte,

and then cross the channel to note the contributions of three Englishmen,

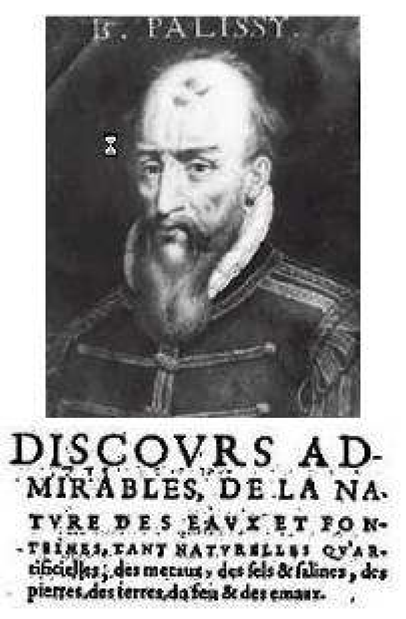
Edmond Halley,
Charles Hutton and
John Dalton.

Three Frenchmen

French Huguenot Bernard Palissy (1509-1590) began his career making stained glass windows and after 16 years of experimentation, perfected an enameled pottery which brought him and his heirs great fortune. An 1880 Palissy factory gravy dish is shown to the left.

Among the first of his nation to embrace Protestantism, had it not been for his patron the High Constable of Saintes, Palissy would have been executed.

But Palissy was more than a successful potter and free thinker. He was a natural philosopher, his theories generally based upon personal observation. Because Palissy was familiar with Vitruvius (Chapter 3), it's likely that the Frenchman lifted ideas from the Roman, but even so, Palissy's substantiation was by contemporary observation carried out with contemporary logic,



B. PALISSY.

DISCOVRS AD-
MIRABLES, DE LA NA-
TVRE DES EAVX ET FON-
TEINES, TANT NATVRELLES QV'AR-
tificielles; des metaux, des ſels & ſalines, des
pierres, des terres, du feu & des emaux.

In his Discours Admirables de la Nature des Eaux Etfonteines (1580, but not translated to English until 1876) Palissy makes use of two voices: Theory, the one who imagines, and Practice, the writer's alter ego, the one who looks.

Theory challenges:

> *Looking back upon the whole body of doctrine taught by the old Potter in the last years of his life, where have you found all this written? Or tell me in what school you have been?*

And Practice responds:

> *I have no other book than the heavens and the earth, which are known of all men, and given to all men to be known and read. Having read in the same I have reflected on terrestrial matters.*

Practice unsuccessfully seeks water from a village spring:

> *When for a long time I had closely considered the cause of the source of natural fountains and the places where they might proceed, at length I became plainly assured that they could proceed from or be engendered by nothing but the rains.*

Theory finds fault:

> *After having heard your opinion, I am compelled to say that you are a great fool. Do you think me so ignorant that I should put more faith in what you say than in so large a number of philosophers who tell us that all waters com from the sea and return thither? There are none even to the old men who do not hold this language, and from time on we have all believed it. It is a great presumption in you to wish to make us believe a doctrine altogether new, as if you were the cleverest philosopher.*

Practice:

> *If I were not well assured in my opinion, you would put me to great shame, but I am not alarmed at your abuse or your fine language, for I am quite certain that I shall win against you and against all those who are of your opinion, though they may be Aristotle and the best philosophers that ever lived, for I am quite assured that my opinion is trustworthy.*

Theory:

> *Verily I find out now that you are a great liar, and if it were true that seawater could be so raised up into the air and fall afterwards upon the earth, it would be salt rain, so there you are caught by your own argument.*

Practice contends that rivers and springs have no source other than rainfall, for which he is called a "great dolt" by Theory for contradicting the most excellent philosophers.

Practice refutes that streams must originate either from seawater or from air converted into water. The concept of gravity weighs against the seawater theory, as sea level would have to exceed the mountain tops.

> *I tell you, as a general and certain rule, that waters never rise higher than the sources from which they proceed.*

Spring waters would be saline and would dry up during low tide. Some rivers do dry up, of course, but,

> *If the sea were to feed by its nipples all the springs of the universe, they would never dry up during the months of July, August and September, at which time an infinite number of wells dry up.*

And as maximum tidal levels are associated with the full moons of March and July, wells and rivers should not go dry during those months.

Even if the sea were as high as the mountains,

> *Its waters would not reach the high parts of these mountains where the springs originate. This is because the earth is, in many places, full of holes, cracks and abysses a through which water that came from the sea would flow back to the plain from the first holes, sources or abysses it could find.*

Practice concedes that water could form in caverns by the condensation of vapor, but in inadequate amount to sustain rivers. Rather,

> *Rain water that falls in the winter goes up in summer, to come again in winter... And when the winds push these vapors the waters fall on all parts of the land, and when it pleases God that these clouds (which are nothing more than a mass of water) should dissolve, these vapors are turned to into rain that falls on the ground.*

Moreover,

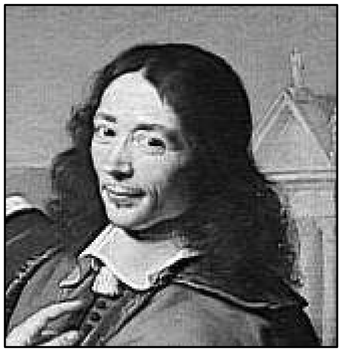
> [Soils] *retain water from the rain as would a bronze vessel. And the said water falling on these mountains flows downwards through the soil and cracks and continues until it finds a uniform and hard bed of stone or solid rock; and when it comes to rest on such a base and finds a canal or other opening, it emerges as springs, or as streams and rivers, depending on the size of the openings.*

Practice has qualitatively described porous-media groundwater flow as we today understand it.

Significant to our pursuit of underground rivers, while Theory clings to idealized subterranean channels, Practice demands a mechanism consistent with how water is observed to seep.

As Palissy concluded (in his own voice),

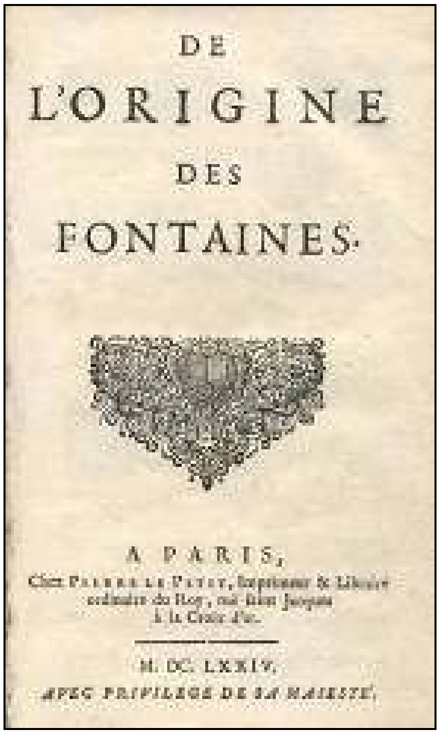
> *When I had long and closely examined the source of the springs of natural fountains, and the place whence they could come, I finally understood that they could not come from or be produced by anything but rains.*



Pierre Perrault (1608-1680), Receiver General of Finances in Paris, studied the River Seine near Burgundy, measuring the average annual rainfall over a small portion of the upper basin for comparison to the annual discharge from that catchment.

The portrait to the right is of Perrault, but as we'll shortly note, we can't be certain that we have the correct sibling.

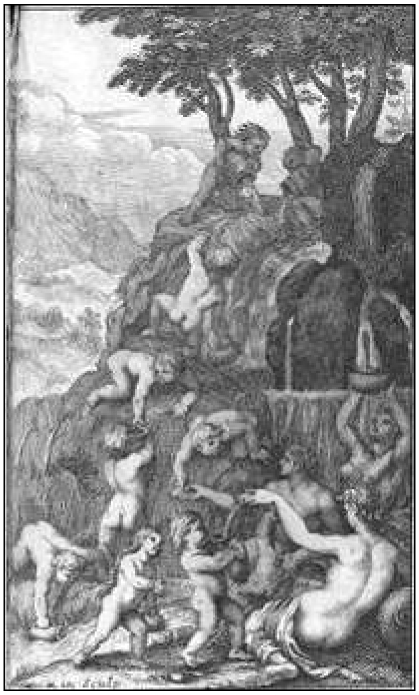
Perrault's De l'Origine des Fontaines (1674) reported that rainfall was six times the amount that flowed out of the watershed, thus proving that precipitation was more than enough to supply the water in the Seine and,



DE
L'ORIGINE
DES
FONTAINES.

A PARIS,

M. DC. LXXIV.
AVEC PRIVILEGE DE SA MAJESTE.



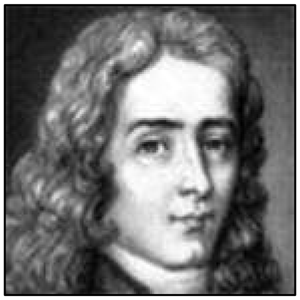
Frontispiece, "De L'origine des Fontaines"

> *To cause this River to flow for one year, from its source to the place designated, and which must serve also to supply all of the losses, such as the feeding of trees, plants, grasses, evaporation…*
>
> *If then this water suffices for one river, it will suffice for all the other rivers of the world in proportion.*

Perrault demonstrated by measurement that capillary rise of water was less than 1 meter in sand and could not create a body of free water above the water table. The revolutionary aspect of Perrault's finding of a 6:1 rainfall/runoff ratio was that the value substantially exceeds unity. Palissy had suggested that rainfall was sufficient to supply the total streamflow, but it took 94 years for Perrault to attach a number.

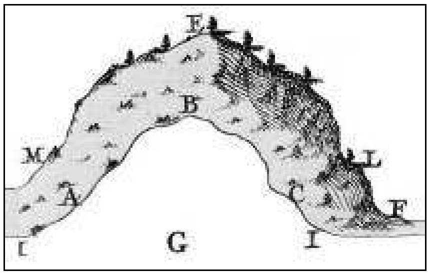
Pierre's brother Claude (1613-1688) was a physician, but became the architect of the Louvre and translated of the ten books of Vitruvius (Chapter 3).

We'll catch up with brother, Charles (1628-1703), in Chapter 17, Underground Rivers in Continental Fiction for his contribution ot the study of underground streams in Tales of Mother Goose (1697).



Edmé Mariotte (1620-1684) refuted the yet-popular assumption of springs derived from condensation in subterranean caverns, as precipitation could not penetrate more than a few meters into the earth.

From Mariotte's Traité du Mouvement des Eaux et des Autres Corps Fluides (1686),



> *For if ABC is a vault in the mountain DEF; it is evident, that if the vapor should become water in the concave of the surface ABC, that water would fall perpendicularly towards HGI, and not towards T or M, and consequently would never make a spring. Besides, it is denied that there are many such hollow places in mountains, and it can't be made appear that there are such. If we say there is earth on the side of, and beneath ABC, it will be answered, that the vapor will gush out at the sides towards A and C, and that very little will become water; and because it appears that there is almost always clay where there are springs, it is very likely that those supposed distilled waters can't pass through, and consequently that springs can't be produced by that means.*

More simply: We won't find subterranean reservoirs behind springs.

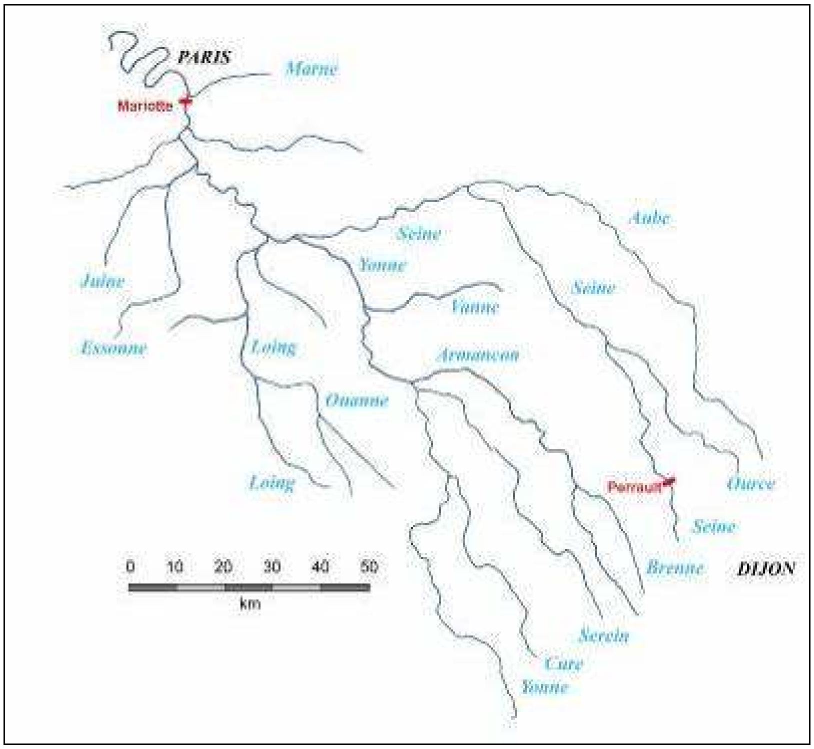
To establish that the source of groundwater must be precipitation, Mariotte compared seepage into the cellar of the Paris Observatory to the rainfall above, noting that more water came into the basement after heavy rains.

> [Rainfall} *filtered through the soil until it met with impervious layers in then interior, through which it was unable to pass; it therefore continued its course along them in an oblique direction until it found egress and came out as springs.*

Scientifically better educated that Perrault, Mariotte sought to confirm Perrault's result using a much larger catchment, that of the Seine at Paris.

> *It is thus evident that when a third of the rain waters have evaporated, a third will keep the soil moist in the large plains, and a third will still b e sufficient to feed springs and rivers.*

As Perrault's and Mariotte's studies were close in both time and location, it is informative to compare their findings.


PARIS
Marne
Mariotte
Seine
Aube
Yonne
Juine
Seine
Vanne
Essonne
Loing
Armancon
Ouanne
Loing
Perrault
Ource
Seine
Brenne
DIJON
Serein
Cure
Yonne
0 10 20 30 40 50
km

The table below summarizes their respective results.

Investigator	Perrault	Mariotte
Publication	De L'origine des Fontaines (1674)	Traité du Mouvement des Eaux et des Autres Corps Fluides (1685)
Basin	Seine above Aignay-le-Duc	Seine above Paris
Area (square km)	121	60,356
Duration of Study	3 years	3 years
Average Precipitation (mm)	520	400
Annual Precipitation (cubic m)	60,750,000	24,142,400,000
Annual runoff (cubic m)	10,000,000	3,553,056,000
Precipitation/Runoff	6.0:1	6.8:1

An historical fact, Claude Perrault was the architect of Versailles and Mariotte, the well-driller. The history of scientific hydrology is indeed one of crossed paths.

Water Tank, Versailles

Current estimates of the precipitation/runoff ratio are summarized below by continents.

	Precipitation (mm)	Evapo-transpiration (mm)	Runoff (mm)	Precipitation/ Runoff
Africa	690	550	140	4.9:1
Asia	720	430	290	2.5:1
Australia	740	510	230	3.2:1
Europe	730	410	320	2.3:1
North America	670	380	290	2.3:1
South America	1650	1060	590	2.8:1

Perrault's and Mariotte's fundamental breakthrough wasn't the precise precipitation/runoff ratio; it was that its value significantly exceeds 1.0. The perception that rivers bear more water than the upstream rainfall was at last disproven.

As well-builder for the Palace of Versailles, Mariotte put his findings to practice. In the world's first application of hydrologic modeling, Mariotte calculated that 100 square kilometers should supply the palace's water need. The channels, however, couldn't transmit the flow and so fared the first application of hydrologic design.

Three Englishmen

English astronomer Edmond Halley (1656-1742), son of an industrial soap-maker, is best remembered for the comet honoring his name, but his most influential contribution to science was that of translating the works of his friend Isaac Newton from Latin to English.

GRENADA
WORLD PHILATELIC PROGRAMMES
Halley publishes Newton's "Principia" 1687

Noting the likeness of comets observed in 1531, 1607 and 1682, Halley concluded that all three were in fact the same object and correctly predicted its 1758 return. Halley's contribution to the science of hydrology stemmed from the condensation on his optical equipment on clear day, 730 meters above the Mediterranean, making the astronomer to be among the first to appreciate the magnitude of atmospheric water.

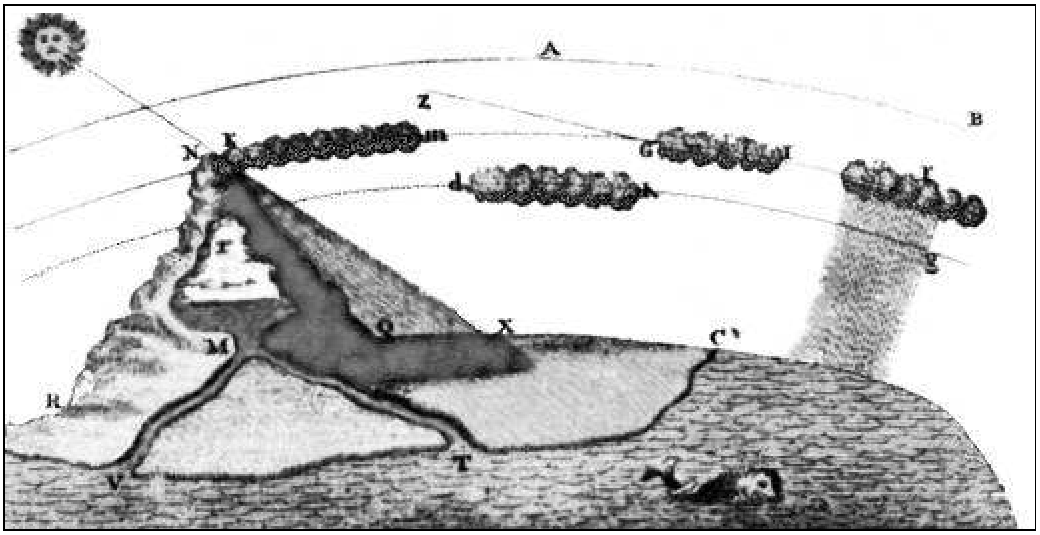
Halley filled a 20-centimeter pan half-full with salt water and heated it to the temperature of a summer day. In two hours, 0.5 ounces were evaporated. Estimating the surface of the

Mediterranean to be 1.9 million square kilometers -- actually, it's 2.5 -- Halley calculated daily evaporation to be 5.3 billion metric tons. (Lest the value seem unduly large, it corresponds to slightly less than 3 millimeters/day. Modern meteorological records averaged over a full year indicate about half that.)

By extrapolating from the estimated flow of the Thames, Halley concluded that evaporation from the Mediterranean exceeds its river inflow and again extrapolated that there is sufficient evaporation from the world's oceans to supply all the rivers and springs.

To bring his numbers into balance, he reported to the Royal Society in 1690 that some of the vapor from the sea swept against the high mountain tops "gleets down by the crannies" and enters into caverns from where it flows back to the sea. Mountains thus act as "external alembics" to distill fresh water for the benefit of man "like so many veins in the microcosm."

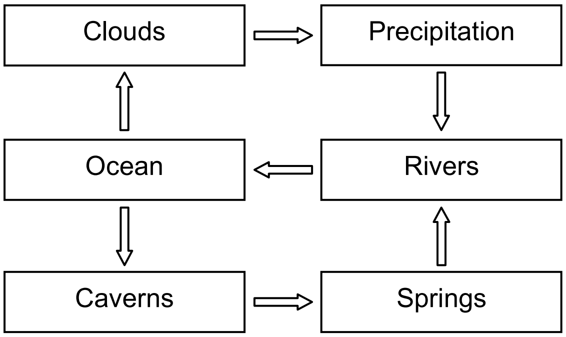
An Estimation of the Quantity of Vapour Raised out of the Sea, and the Cause of Springs (1687) illustrates the caverns and rivers.



Halley wasn't willing to place his entire bet with the rainfall hypothesis. To explain how springs continued to flow during periods when there was no rain,

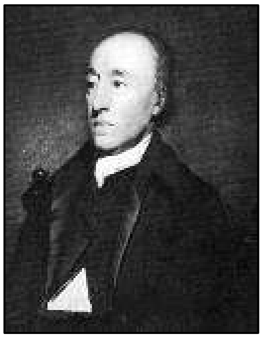
> *Those Vapors therefore that are raised copiously in the Sea, and by the Winds are carried over the low Land in those Ridges of Mountains, are there compelled by the stream of the Air to mount up with it to the tops of the Mountains, where the Water presently precipitates, gleeting down by the Crannies of the stone; and part of the Vapour entering into the Caverns of the Hills, the Water thereof gathers as in an Alembick into the Basons of stone it finds, which being once filled, all the overplus of Water that comes thither runs over by the lowest place, and breaking out of the sides of the Hills, forms single Springs.*
>
> *I doubt not but this Hypothesis is more reasonable than that of those who derive all Springs... from a Filtration of Percolation of the Sea-waters through certain imaginary Tubes or Passages within the Earth, wherein they lose their saltness.*-- "An Account of the Circulation of the Watery Vapors of the Sea, and of the Causes of Springs," Philosophical Transactions of the Royal Society (1686)

Below is Halley's hydrologic model showing the caverns-springs-rivers route.



We will return to Halley's condensation hypothesis as it relates to caves in Chapter 39, but before then, we'll meet the astronomer looking further downwards in Chapter 14, Hollow Earth Geophysics.

Charles Hutton (1737-1823) was an encyclopedist, striving to sort the burgeoning set of scientific findings into an objective framework. Following are several entries from his A Mathematical and Philosophical Dictionary, Containing an Explanation of the Terms, and an Account of the Several Subjects (1795).



As to what would become to be today's common understanding of the hydrologic cycle,

> *The most general and probable opinion among philosophers, on the formation of Springs, is, that they are owing to rain. The rain-water penetrates the earth till such time as it meets a clayey soil, or stratum; which proving a bottom sufficiently solid to sustain and stop its descent, it glides along it that way to which the earth declines, till, meeting with a place or aperture on the surface, through which it may escape, it forms a Spring, and perhaps the head of a stream or brook.*

Regarding Perrault's 6:1 rainfall/runoff ratio,

> *Now, that the rain is sufficient for this effect, appears from hence, that upon calculating the quantity of rain and snow which falls yearly on the tract of ground that is to furnish, for instance, the water of the Seine, it is found that this river does not take up above one sixth part of it.*

Hutton understood enough basic hydraulics to envision the upper slopes of a nearby mountain feeding a geologic stratum that curves below nearby valleys to rise elsewhere.

> *And if we sometimes see Springs on high grounds, and even on the tops of mountains, they must come from other remoter places, considerably higher, along beds of clay, or clayey ground, as in their natural channels. So that if there happen to be a valley between a mountain on whose top is a Spring, and the mountain which is to furnish it with water, the Spring must be considered as water conducted from a reservoir of a certain height, through a subterraneous channel, to make a jet of an almost equal height.*

Hutton, however, perpetuated Halley's subterranean cavern theory.

> *The tops of mountains usually abound with cavities and subterraneous caverns, formed by nature to serve as reservoirs; and their pointed summits, which seem to pierce the clouds, stop those vapors which float in the atmosphere; which being thus condensed, they precipitate in water, and by their gravity and fluidity easily penetrate through beds of sand and the lighter earth, till they become stopped in their descent by the denser strata, such as beds of clay,*

> *stone, &c, where they form a basin or cavern, and working a passage horizontally, or a little declining, they issue out at the sides of the mountains.*

Refuting those who hold to underground rivers from the sea,

> *Some naturalists therefore have recourse to the sea, and derive the origin of Springs immediately from thence. But how the sea-water should be raised up to the surface of the earth, and even to the tops of the mountains, is a difficulty, in the solution of which they cannot agree.*

Regarding Halley's condensation caves,

> *Others... set aside the alembics, and think it enough that there be large subterranean reservoirs of water at the height of the sea, from whence the warmth of the bottom of the earth, &c, may raise vapours; which pervade not only the intervals and fissures of the strata, but the bodies of the strata themselves, and at length arrive near the surface; where, being condensed by the cold, they glide along on the first bed of clay they meet with, till they issue forth by some aperture in the ground.*

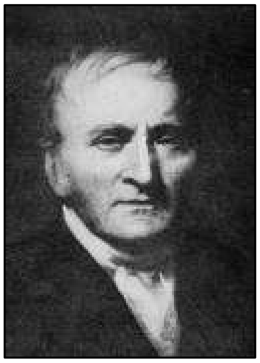
In support of Perrault's rainfall-alone explanation,

> *The water that is supposed to ascend from the depths of the sea, or from subterranean canals proceeding from it, through the porous parts of the earth, as it rises in capillary tubes, ascends to no great height, and in much too small a quantity to furnish springs with water, as Perrault has sufficiently shewn.*

As they share the same surname, perhaps here we should mention the Rev. John Hutton, who wrote on the subject a century later. The latter Hutton's A Tour to the Caves, in the Environs of Ingle Borough and Settle, in the West-Riding of Yorkshire (1880, 1881) noted two underground streams crossing without mixing.

> *The springs were entirely dependent on the rains.*
>
> *Though we met with many streams below the earth; yet we could easily find they originally descended from its surface, and not from any distillations against the sides of the caves.*

Much had indeed be learned between Hutton I and Hutton II.



Over his lifetime, John Dalton (1760-1844) made over 200,000 meteorological observations, the basis of his Experiments and Observations to Determine Whether the Quantity of Rain and Dew is Equal to the Quantity of Water Carried off by the Rivers and Raised by Evaporation, with an Enquiry into the Origin of Springs (1802).

After correction for missing areas, Dalton estimated the mean rainfall and snowfall (water equivalent) for England and Wales to be 79 centimeters. He added 13 centimeters for annual dewfall. To estimate the total river outflow, he divided the country into catchments and from the flow of the Thames and the relative sizes of the watersheds, obtained 33 centimeters.

Dalton monitored the long-term water balance of a soil-filled container to estimate 76 centimeters for the annual evapotranspiration loss.

79 centimeters of rain and snow
+ 13 centimeters of dew
92 centimeters of inflow

33 centimeters of streamflow
+ 76 centimeters of evaporation
109 centimeters of outflow

Dalton attributed the discrepancy to overestimated evaporation and non-representativeness locations.

> *Upon the whole then I think that we can finally conclude that the rain and dew of this country are equivalent to the quantity of water carried off by evaporation and by the rivers. And as nature acts upon general laws, we ought to infer, that it must be the case in every other country until the contrary is proved.*

Dalton's finding is a prime example of Ockham's Razor, Chapter 10. When choosing between conflicting, but incompatible, explanations, the simper of the explanations is more likely to be the better. Dalton's finding calls upon but four quantifiable hydrologic estimates, no unseen routes or mechanisms and no unique physical relationships.

We should not close this chapter secure that science has triumphed, however. Skepticism is too much a part of human nature. Nearly a century later, the German geologist Otto Volger (1822-1897) in The Scientific Solution to the Water Issue with Respect to the Supply of Cities (1877) categorically denied any relation between rainfall and groundwater. Volger also maintained that concern for groundwater contamination was a fear of phantoms which would impose unnecessary costs on public water wells.

We began this chapter with a list of fallacious hydrological propositions commonly held until the time of Newton.

1. Mechanisms such as wind, capillary action or wave action can draw large quantities of water from the earth’s interior.
2. Sea water can lose its salt by infiltrating through soil.
3. Rainfall is insufficient to account for all water discharged by rivers.
4. Rainfall can not infiltrate into the ground in large quantities.

Rudimentary measurements disprove all four.

An ocean-to-mountain underground river becomes unnecessary when rainfall exceeds streamflow. It seems, therefore -- if we allow ourselves a bit of reflection -- that Chapters 8-10 was spent looking for engines that need not exist.

The fifth perception, however, yet eluded testing.

5. The earth contains a large network of caverns and rivers.

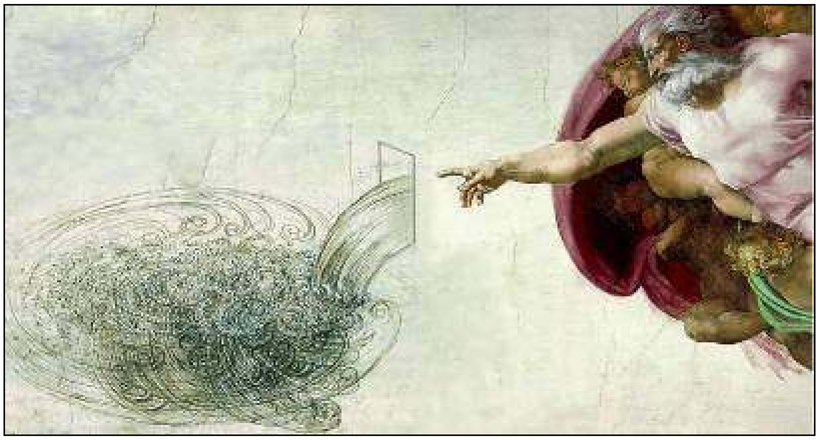
Eliminating hydrologic necessity for underground rivers does not dispel the possibility of their existence.

Did quantifying the hydrologic cycle remove underground rivers from theological interest?

Not at all. As we will see in the next chapter, it confirmed Christianity.

CHAPTER 13

HYDROTHEOLOGY/THEOHYDROLOGY



"Idroteologia/Teoidrologia"(1504),
Leonardo da Vinci and Michelangelo

Revealed for the first time in this very book, the above collaboration is dated by the single recorded meeting between the artists. Scholars consider this work to be the penultimate Renaissance artwork, the definitive tie between hydrology and theology.

The challenge in da Vinci's and Michelangelo's time was that of reconciling Aristotelian cosmology with new-found Humanism. Two centuries later, the challenge had shifted to that of that of validating Biblical inerrancy in an increasingly-quantifiable terrestrial sphere.

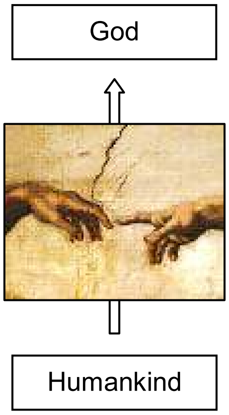
There are three general phases in theology's adjustment to human experience.

1. Scriptural dismissal of unsettling evidence. We saw this in Chapter 4, The Cross.
2. Floundering dogma. Christendom was intellectually challenged by Renaissance thought, the subject of Chapter 7.
3. Textual reconciliation with ascertained fact. Seventeenth-century theologians sought attributes of God in the heavens (astronomy), the inhabitants (biology), and the earth (geology). This chapter is about how nature's hydrologic wisdom came to serve Judeo-Christianity as an object lesson.

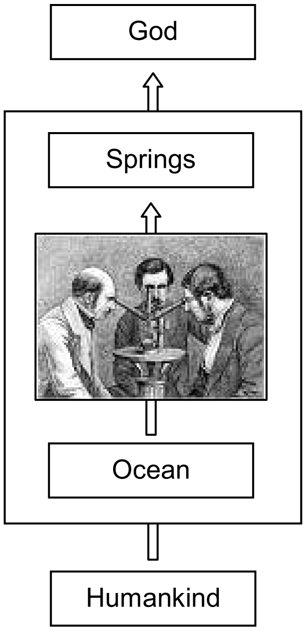
The challenge in da Vinci's time was that of reconciling Aristotelian cosmology with new-found Humanism. Two centuries later, the challenge had shifted to that of that of validating Biblical inerrancy in an increasingly-quantifiable terrestrial sphere.

"Revealed theology" seeks God's truth above reason, decreed by God and formulated by God's sacred institutions. "Natural theology" or "physicotheology" seeks God's truth through Aristotelian observation and logic. It being the 17th century, from either perspective the truth was of course God's truth.

And what could better prove God's grace than God's setting natural perpetuity the replenishment of that which sustains human kind, the hydrologic cycle?


God
Humankind

Revealed Theology


God
Springs
Ocean
Humankind

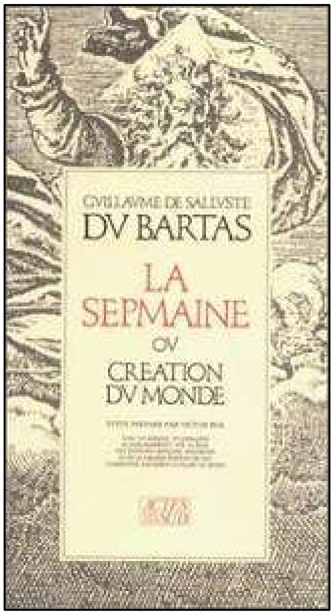
Natural Theology

Biblical revelation in one hand and instruments of hydrologic measurement in the other, the Christian apologist could sally forward.

> *But thou hast ordered all things in measure, and number, and weight. -- Wisdom 11:21*

La Sepmaine, ou, Creation du Monde (1578) by Guillaume de Salluste du Bartas (1544-1590), a Huguenot, was an influential account of Creation. On the seventh day, God invented the hydrologic cycle.

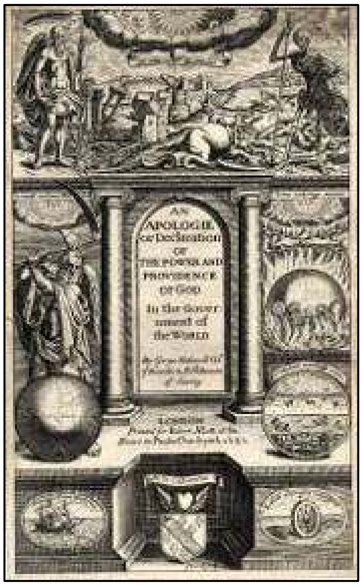
One while, hee sees how the ample Sea doth take
The Liquid homage of each other Lake;
And how again the Heav'ns exhale, form it,
Aboundant vapors (for our benfit).
And yet it swels not for those tribute streams,
Nor yet it shrinks not for those boyling beams.


GVILLAVME DE SALLVSTE
DV BARTAS
LA SEPMAINE
OV
CREATION
DV MONDE

The cycle exemplifies how the balance of Creation provides for man.

An Apologie (1627) by English clergyman George Hakewill (1578-1649) asserted that, "The Power and Providence of God in the Government of the World" and censured, "the common Error touching Natures Perpetuall and Universall Decay." Behind Hakewill was the "weightie authoritie" of Solomon, "the wisest man that ever lived," and "his reason drawne from the Circulation of all things as it were in a ring."

How often, Hakewill noted, does Solomon "beat upon the circulation and running round of all things." Both the wind and the water move in circuits. "Whereupon hee inferres, the thing that hath beene, it is that that shall bee, and that which is done, is that which shall be done, and there is no new thing under the Sunne."

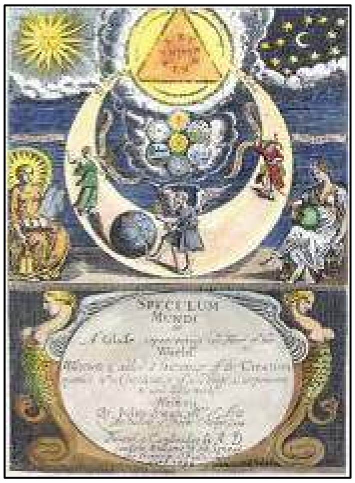


Specific to the theohydrology of underground rivers, we turn to another member of the English clergy, John Swan (d. 1671), author of Speculum Mundi (1635), or

> *A glasse representing the face of the world: shewing both that it did begin, and must also end: the whole of which may be fitly called an hexameron or discourse of the clauses, continuance, and qualities of things in nature, occasioned as matter pertinent to the work done in the six dayes of the world's creation.*

The frontispiece, rife with esoteric symbolism, is shown to the right.

Swan's encyclopedic tome arrangement of science according to the six days of creation embodies the conflict between science and scripture, superstition and belief.



The air is now "corrupted" and the "fruits of the earth of a feeble nourishment." The Flood wrought damage through the action of "the salt waters of the great deep," and also by way of "vapors or... Exhalations."

Swan's answers to six self-addressed hydrological questions are excerpted below.

1. *How the waters were gathered together?*

   For the efficient cause of the sea was the onely word of God.

2. *How it can be said that they were gathered to one place; seeing there be many seas, lakes, rivers, and fountains that are farre asunder?*

   Every part of the water is joyned unto the whole as it were with arms and legs, and veins diversely dilated and stretched out.

3. *Whether they be higher than the earth?*

   Suppose that certain springs arise out of the highest mountains, must the sea therefore needs be higher than those mountains? Surely I think not. For albeit I be not of Aristotles minde, nor of their opinions who do not derive the rivers from the seas, nor make subscription onto them

> *who give a sucking and an attractive power to the veins of the earth; yet I find it as a thing possible, although that part of the sea which lieth opposite to the heads of the fountain, or to a place where the water first breaketh out, be lower than the ground, that the said water may neverlesse easily ascend, and not break forth untill it finde a place convenient. Now this ascent is caused by the sea, which, seeing it is a vast bodie, is very ponderous and heavie, and cannot be thrust back by the waters at the head of the fountain opposite to it, but rather it doth potently and strenuously croud on the said water through the hollow ports and passages of the earth, untill at the last is springeth forth.*

It's the weight-of-the-sea engine, a proposed subterranean engine we reviewed in Chapter 10.

4. *Whether there be more water than earth?*

   When God commanded the waters to be gathered, he gathered them into the seventh part of the earth, and dried up the six other parts.

5. *Whether the earth can be founded upon the waters?*

   The Psalmist seemeth of affirm it.

6. *Why the seas be salt, and the rivers fresh?*

   If therefore Aristotle's aerial vapors have anything to do in this generation, it is as much as nothing.

   This freshness, notwithstanding their salt origin, may be ascribed to percolation and straining through the narrow spongie passages of the earth, which makes them leave behind (as an exacted toll) the colour, thickness, and saltness.

We're familiar with Chapter 11's salt-straining earth.

7. *What causeth an ebbing and flowing in the sea, rather than in rivers?*

   It is a great secret of nature, and gives us therefore principall occasion to magnifie the power of God, whose name onely is excellent, and whose power above heaven and earth.

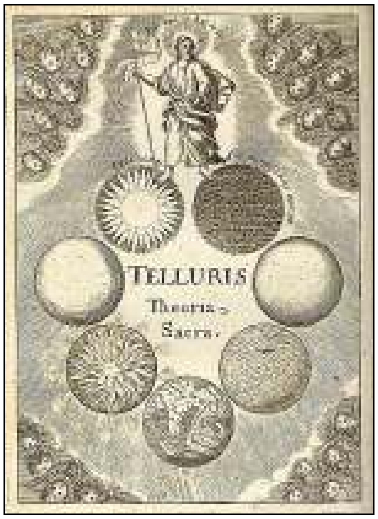
As revealed theology, Speculum offered little not already centuries old. As natural theology, it relied on science already disproven. We'll give Swan credit, however, for a start at bridging the gap.

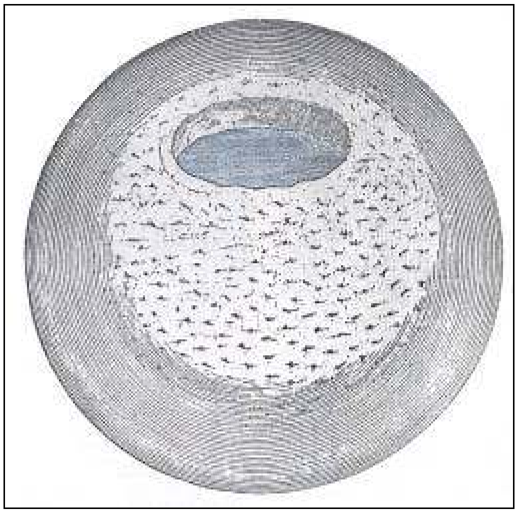
Neoplatonist and royal chaplain to William III, Thomas Burnet (1635-1715) sought to explain,

> *The origin of the earth, and all of the general changes which it hath already undergone or is to undergo till the consummation of all things.*

Burnet's Telluris Theoria Sacra (1684) tells how the earth was first fluid chaos until the heavier parts sunk to form a fiery core, leaving a thin earthen crust upon a watery abyss. The earth was of perfect mathematical form, smooth and beautiful, "like an egg," with neither seas nor islands nor valleys nor rocks, "with not a wrinkle, scar, or fracture."

All creation was equally perfect. There were no alternating seasons, storms or rivers. It rained only at the poles from where the water filtered into the soil and flowed underground to the inhabited tropics.





But sin led to the breaking up of the "foundations of the great deep" and the fertile superficial layer was dried by the sun and began to crack until the colder waters below burst upward, causing mountains, abysses and islands. Had there been a sea before the deluge, sinners would have learned to build ships and could have saved themselves.

When the earth's crust collapsed, air was trapped under the rubble, but with time, the air escaped and was replaced by waters connected by underground passages. To visualization such,

> *We must take off the cover of all Subterraneous places and deep Caverns, to see the inside of the Earth; and lay bare the roots of Mountains, to look into those holes and Vaults that are under them, fill'd sometimes with Fire, sometimes with Water, and sometimes with thick Air and Vapours.*

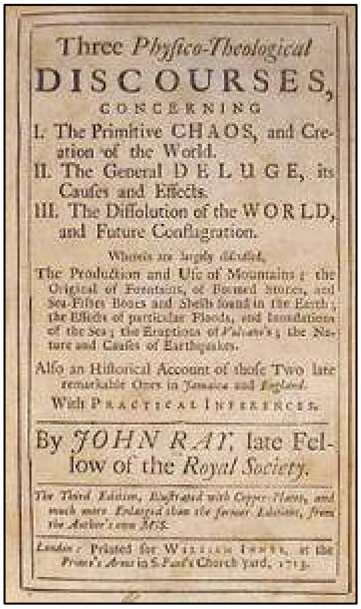
It is Genesis retold per the science of the day. We're familiar with the Great Abyss from Greek myth to Renaissance thoughts, but to Burnet, it's sermon material.

When God created heaven and earth, He also created underground rivers. If they don't service us as well as they used to, it's because of our sin.

John Ray (1628-1704), a devout Anglican, was a forerunner of Linnaeus in biological taxonomy. Born the son of a blacksmith, Ray became professor of Greek at age 20 and later a professor of mathematics. Three Physico-Theological Discourses (1693) ponders the wonder of the earth.

> *The Sea, what infinite Variety of Fishes doth it nourish! How doth it exactly compose itself to a Level, of equal Supercies, and in the Earth make one spherical Roundness? How doth is constantly observe its Ebbs and Flows, and still retain its Saltiness, so convenient for the maintenance of its Inhabitants, serving also the Uses of Man for Navigation, and the Convenience of Carriage?*

Ray's Three Physico-Theological Discourses refuted Burnet's view of mountains as blemishes on the earth's surface. Among such other benefits to humanity, mountains provide boundaries, produce springs and rivers and contain caves providing refuge for Christians.



Three *Phyſico-Theological*
DISCOURSES,
CONCERNING
I. The Primitive CHAOS, and Creation of the World.
II. The General DELUGE, its Cauſes and Effects.
III. The Diſſolution of the WORLD, and Future Conflagration.
Wherein are largely diſcuſs'd,
The Production and Uſe of Mountains; the Original of Fountains, of Formed Stones, and Sea-Fiſhes Bones and Shells found in the Earth; the Effects of particular Floods, and Inundations of the Sea; the Eruptions of *Vulcano's*; the Nature and Cauſes of Earthquakes.
Alſo an Hiſtorical Account of thoſe Two late remarkable Ones in *Jamaica* and *England*.
With PRACTICAL INFERENCES.

By *JOHN RAY*, late Fellow of the *Royal Society*.

The Third Edition, Illuſtrated with Copper-Plates, and much more Enlarged than the former Editions, from the Author's own MSS.

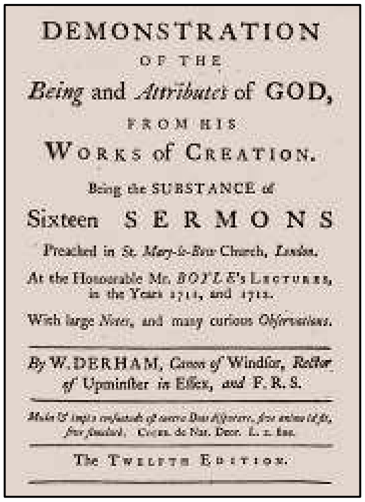
London: Printed for WILLIAM INNYS, at the *Prince's Arms* in *S. Paul's* Church-yard, 1713.

To Ray, the hydrologic cycle was a unifying concept that incorporated a remarkable range of facts. In light of his own observations and the findings of Perrault and Mariotte, Ray supported the pluvial theory by correlating the relative size of watersheds to the magnitudes of their respective streams and rivers.

Anglican clergyman William Derham (1657-1735) presented the wonders of nature as proof of God's existence in two works: Physico-Theology, or A demonstration of the Being and Attributes of God (1713) and Astrotheology (1714).

Physico-Theology, even more popular than Ray's Wisdom of God, strove to show, how all facets of physical geography interactively give evidence of "the most indulgent Creator." Derham cited a spring in his own parish which he perceived undiminished even when all the ponds in the country and all the adjoining brooks had been dry for months. Likewise then spring never increased in the rainy seasons, except for a few hours after violent rains. Had the spring, he judged, originated from rain or vapors, there would be change corresponding to such causes.

Praise be to God for the underground stream.



DEMONSTRATION
OF THE
Being and *Attributes* of GOD,
FROM HIS
WORKS of CREATION.
Being the SUBSTANCE of
Sixteen SERMONS
Preached in *St. Mary-le-Bow* Church, *London*.
At the Honourable Mr. *BOYLE*'s LECTURES, in the Years 1711, and 1712.
With large *Notes*, and many curious *Obſervations*.

By W. DERHAM, *Canon of* Windſor, *Rector of* Upminſter *in* Eſſex, *and* F. R. S.

The TWELFTH EDITION.

Johann Albert Fabricius (1668-1736), a Lutheran, wrote Hydrotheologie (1734), a three-part treatise on the interaction within the whole of nature.

> *The owners of water, his nature, its quantity, the depth of the sea, the mixtures of water with other substances.*
>
> *The wise and liberal dispensation of Water in the world, the rivers, lakes, ponds, the water underground and the human exploitation thereof.*
>
> *The movement of water in the air, in the sea and in rivers and its use in cooking, boiling, distillation and perspiration.*

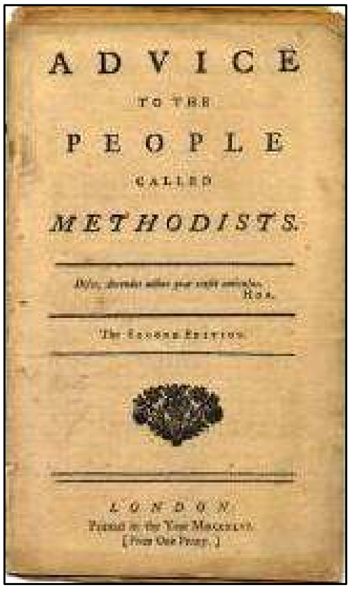
Hydrology is anthropocentric, the means by which God has chosen to sustain His people.

HYDROTHEOLOGIE
Oder
Verſuch,
durch aufmerkſame Betrachtung
der Eigenſchaften, reichen Austheilung
und Bewegung
Der Waſſer,
die Menſchen
zur Liebe und Bewunderung
Ihres Gütigſten, Weiſeſten,
Mächtigſten Schöpfers
zu ermuntern.
Ausgefertiget
von
JO. ALBERTO FABRICIO,
D. und Prof. Publ. des Gymnasii zu Hamburg.
Nebſt einem Verzeichniß von alten und neuen
See- und Waſſer-Rechten,
wie auch Materien und Schriften, die dahin gehören, unter XL. Titul gebracht.
Hamburg, bey König und Richter, 1734.

John Wesley (1703-1791), the evangelist known for his advocacy of Methodism, also applied his prodigious preaching skill to the subject of earth science. Based on the Almighty finding the earth and all created things "very good," Wesley declared in a 1750 sermon that no one can deny that "sin is the moral cause of earthquakes, whatever their natural cause may be."

Regarding the provision of water on the land, Wesley's attributed the larger role to evaporation.

> *That the vapour rising from the sea, are more than sufficient to supply both the surface of the earth, and the rivers with water.*
>
> *That the mountains, by their particular structure, arrest the vapors that float in the atmosphere, and having collected them in their reservoirs, dismiss them again through their sides, either in perpetual or intermitting currents.*



ADVICE
TO THE
PEOPLE
CALLED
METHODISTS.
HOR.
The SECOND EDITION.
LONDON:
Printed in the Year MDCCXLV.
[Price One Penny.]

But, cognizant of Ecclesiastes, Wesley's A Survey of the Wisdom or God in Creation (1763) added,

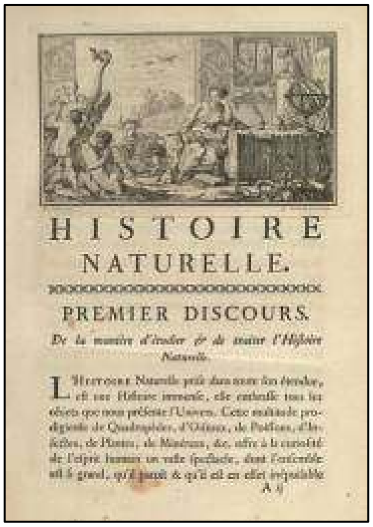
> *And yet we need not deny, that some springs may arise from the sea, or the great abyss, those in particular, which at all times afford the same quantity of water.*

Once again, the ancient tale.

George Louis Lecrec Buffon (1707-1788), a Catholic, translated Newton's Principia into French and directed what was to become Paris' Museum of Natural History. In Théorie de la Terre, the first volume of Histoire Naturelle (1749), Buffon assumed not a geo-central fire, but rather subterranean fire-hearths directly linked to volcanoes and earthquakes. It's a Kircher graphic of Chapter 9.

Buffon argued that the earth was impermeable at a depth beyond four feet where rainwater stagnates until flowing out as springs. "Each river is a large lake that stretches out far underground." is not far from sounding like an alluvial aquifer, but in this case, he appears to have meant a literal lake.

Nature's service to mankind is proof of God's wisdom. That underground rivers -- having never been actually observed -- did not technically qualify as "phenomena" wasn't of concern on Sunday.



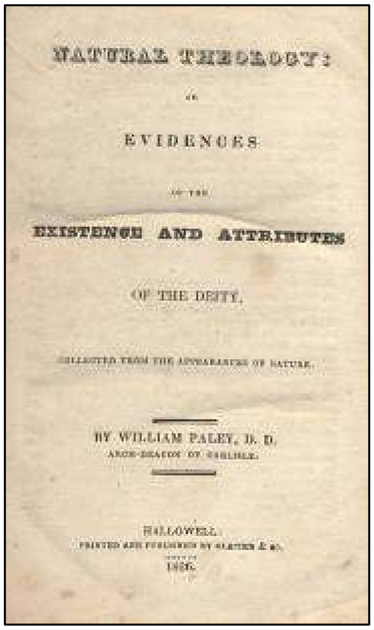
HISTOIRE
NATURELLE.

PREMIER DISCOURS.

De la manière d'étudier & de traiter l'Histoire Naturelle.

While Anglican William Paley (1743-1805) offered no particular insight regarding underground waters, we can't skip his Natural Theology, or Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature (1802) in which was introduced the famous metaphor of the watchmaker.

> *When we come to inspect the watch, we perceive... that its several parts are framed and put together for a purpose, e.g., that they are so formed and adjusted as to produce motion, and that motion so regulated as to point out the hour of the day; that if the different parts had been differently shaped from what they are, or placed after any other manner or in any other order than that in which they are placed, either no motion at all would have been carried on in the machine, or none which would have answered the use that is now served by it... the inference we think is inevitable, that the watch must have had a maker -- that there must have existed, at some time and at some place or other, an artificer or artificers who formed it for the purpose which we find it actually to answer, who comprehended its construction and designed its use.*

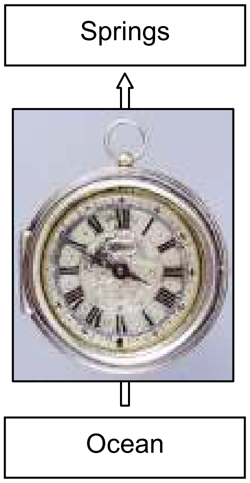


NATURAL THEOLOGY:
OR
EVIDENCES
OF THE
EXISTENCE AND ATTRIBUTES
OF THE DEITY,
COLLECTED FROM THE APPEARANCES OF NATURE.

BY WILLIAM PALEY, D. D.
ARCH-DEACON OF CARLISLE.

HALLOWELL:
PRINTED AND PUBLISHED BY GLAZIER & CO.
1826.

If God has taken such care in guiding the machine of nature, how much more must He care for us wretched sinners!



In the subsequent two centuries, has Paley's watchmaker faded from the public eye?

John Archibald Wheeler (1911-2008), student of Niels Bohr, colleague of Albert Einstein, teacher Richard Feynman and coiner the term "black hole," re-popularized the watchmaker analogy with the premise for what's come to be known as Intelligent Design. A "life-giving factor lies at the center of the whole machinery and design of the world."

The alliance between God and the hydrologic cycle seems as strong as ever.

CHAPTER 14

HOLLOW EARTH GEOPHYSICS

This chapter describes hollow earth geophysical hypotheses based scientific conjecture, as opposed to a pseudo-scientific hollow globe described in popular fiction.

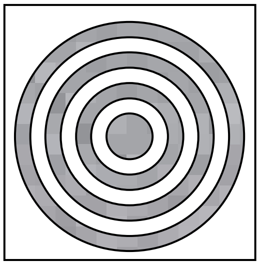
We'll first take our look at the geophysics of such worlds, and then be made parly to perhaps the greatest geophysical secret ever, the Polar Hole.

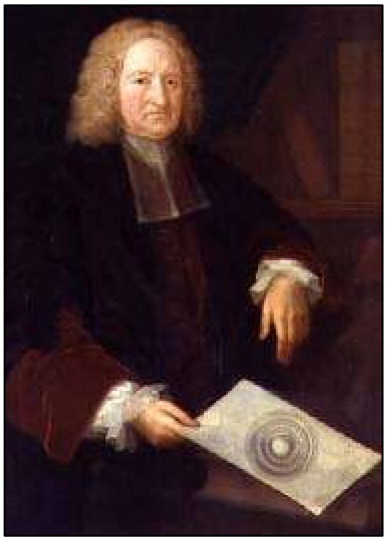
The Geophysics

We first met Edmund Halley (1656-1742) in Chapter 12 where his estimation of evaporation helped quantify the hydrologic cycle as we now know it. Halley was likewise interested in the earth's magnetic field, concluding "that the Globe of the Earth might be supposed to be one great Magnet, having four Magnetical Poles or Points of Attraction" -- Philosophical Transactions of the Royal Society (1683).

> *No Magnet I had ever seen or heard of had more than two opposite Poles, whereas the Earth had visibly four, and perhaps more...* [and] *these Poles were not, at least all of them, fixt in the Earth, but shifted from place to place…whereas it is not known or observed that the Poles of a Load-Stone ever shifted their place in the Stone.*
>
> [The cause of geomagnetism must] *turn about the Centre of the Globe, having its Centre of Gravity fixt and immoveable in the same common Centre of the Earth, [but must be] detached from the external parts.*
>
> *In order to explain the change of the Variations, we have adventured to make the Earth hollow and to place another Globe within it; and I doubt not but this will find Opposers enough. I know 'twill be objected, That there is no Instance in Nature of the like thing; That if there was such a middle Globe it would not keep its place in the Centre, but be apt to deviate therefrom, and might possibly chock against the concave Shell, to the ruine or at least endammaging thereof; that the Water of the Sea would perpetually leak through, unless we suppose the Cavity full of Water.*

The solution: a hollow earth of concentric shells, not unlike the yet-to-be-invented dynamo. The outer shell is 500 miles thick. Drawing upon his planetary knowledge, Halley determined that the two inner shells have diameters comparable to Mars and Venus and the solid inner core is the size of Mercury.



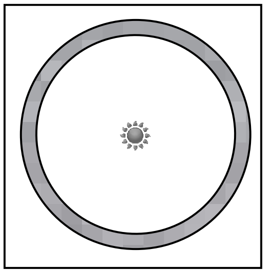


Bathed in perpetual light from a luminous gaseous atmosphere that filled the inner spaces, each sphere "might support life." Halley even entertained the possibility of "more ample creation" within the earth, which might include suns. Surely God would provide no less for his creatures. In the very year that Halley's essay was published, Robert Boyle initiated a lecture series dedicated to the scientific proof of Christianity. As Halley had recently been charged with "atheism" -- a term holding different connotations than it does today -- the nod to the Almighty may have been politically astute.

Halley at 80, holding a drawing of his hollow earth.

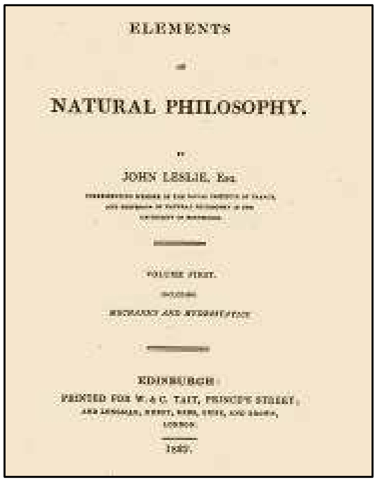
Swiss mathematician Leonard Euler (1707-1783) speculated about a hollow earth in 1767, proposing a thought experiment in which at the earth's center lies a glowing core which serves as a miniature sun for interior inhabitants.

It's unlikely that Euler believed any such thing, but subsequent public perception often differs from individual initial intent.



John Leslie (1766-1832) wrote "The Philosophy of Arithmetic," but is best known for his research on heat and is considered to be the first scientist to properly describe capilarity -- a geophysical mechanism we saw much abused in Chapter 10.

Every genius has his or her shortcomings, Leslie's being a theory of compressible bodies holding that density to be a function of both a substance's particular elastic properties and its distance from earth's center. Material at the earth's core would be thousands of times more massive than that allowed by Newtonian physics.

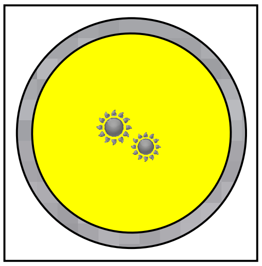


ELEMENTS
OF
NATURAL PHILOSOPHY.
BY
JOHN LESLIE, Esq.

VOLUME FIRST.
INCLUDING
MECHANICS AND HYDROSTATICS

EDINBURGH:
PRINTED FOR W. & C. TAIT, PRINCE'S STREET;

To make the math work, Leslie proposed in Elements of Natural Philosophy (1829) that, "Our planet, must have a very widely cavernous structure," and "we tread on a crust or shell whose thickness bears but a very small proportion to the diameter of its sphere." As nothing can be stationary, a single interior star couldn't be the source, but binary stars (which he named Pluto and Proserpine) resolved that problem.



Because an absolute vacuum was inconceivable, something must fill the intraplanetary void. It couldn't be air, because near the center, even air would be subject to*,*

> *Immense compression* [that] *would totally derange the powers of elective attraction, and change the whole form and constitution of bodies.*

Rather*,*

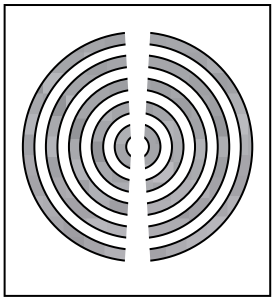
> *The vast subterranean cavity must be filled with some very diffusive medium, of astonishing elasticity or internal repulsion among its molecules.*

This left only one possibility,

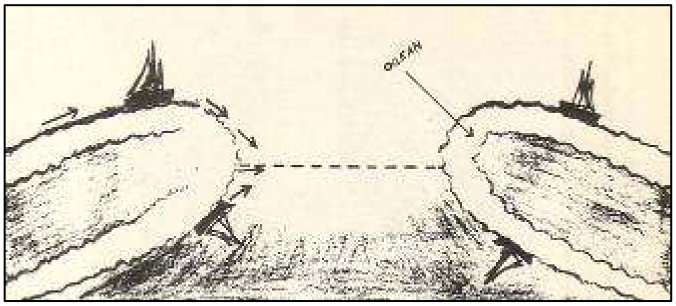
> [The] *only fluid we know possessing that character is LIGHT itself.*

To illustrate Leslie's point, we've added the color yellow.

The American John Cleves Symmes, Jr. (1779-1829), an officer from the War of 1812, may have learned of Halley's theory by way of Cotton Mather's The Christian Philosopher (1721). To this, Symmes added entrances 6,600 and 10,000 kilometers in diameter at the two poles, suffice to allow the expulsion of Leslie's light and the inflow of air.



A confused gravity allows the dwellers to inhabit either side of each shell. A ship at the polar hole would simply sail around the rim and onto the shells inside ocean, masts now pointing toward the geo-center. Polar access, detailed by Max Fyfield, is shown to the right.



It's all about pressure,

> *…thus causing a universal pressure, which is weakened by the intervention of other bodies in proportion to the subtended angle of distance and dimension, necessarily causing the body to move toward the points of decreased pressure.*

In an 1818 circular sent "TO ALL THE WORLD," Symmes proposed,

> *I declare the earth is hollow, habitable within; containing a number of solid concentric spheres; one within the other, and that it is open at the pole twelve or sixteen degrees. I pledge my life in support of this truth, and am ready to explore the hollow if the world will support and aid me in the undertaking.*
>
> *I ask one hundred brave companions, well equipped, to start from Siberia in the fall season, with Reindeer and slays, on the ice of the frozen sea; I engage we find a warm and rich land, stocked with thrifty vegetables and animals if not men, on reaching one degree north-ward of latitude 62; we will return in the succeeding spring.*

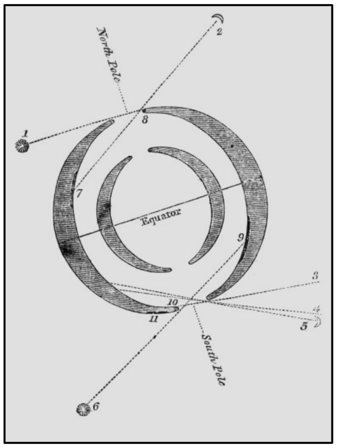
One might wonder about the vegetables, but Symmes was prepared. As flora would require additional light, there may exist non-polar openings in uninhabited parts of South America, northern Asia, Canada and Alaska, Iceland and Greenland.

Noting that other things in nature are likewise hollow -- bones, reeds and hair, for example -- and using spherical bowls of sand, magnets and iron filings to demonstrate his physics, Symmes carried his case to the public.

A Symmes' advocate proposed to the United States Congress an expedition to the earth's interior to open profitable trade with the natives. As Congress preferred to explore the West, not the Under, however, the proposal was defeated, 56 to 46.

By 1824, Symmes had abandoned the idea of multiple concentric spheres in favor of a single hollow shell. Late in life, Symmes sought to join a Russian polar expedition, but could not raise the passage to St. Petersburg.

Capt. Adam Seaborn's Symzonia, Voyage of Discovery (1820) is an account of how the author sailed over the rim of the world and into the interior where there appear two suns and two moons, refractions from the exterior. Seaborn's identity is unknown but most believe nom to have been Symmes himself. Others identify the author as Nathanial Ames who wrote other works, including one that may have served as the inspiration of Moby Dick.

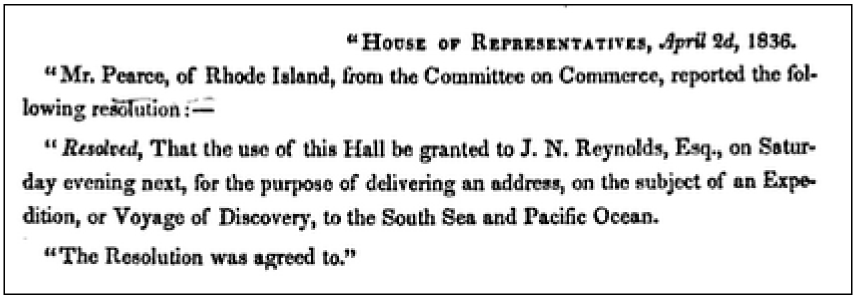


A monument erected over Symmes' grave, a hollow earth model at its top, stands today in the center of Fourth Street Park, Hamilton, Ohio, just south of the business district.

Symmes died, but not his advocates, one being newspaper editor Jeremiah Reynolds, whose hollow-earth lectures were favorably received in Philadelphia, Baltimore, Boston and New York.

In 1828, Reynolds approached Navy Secretary Samuel Lewis Southard, who in turn convinced President John Quincy Adams to mount the "Great American Exploring Expedition" in search of, among such other things, a hole into the hollow earth. States-rights Democrats delayed the expedition until 1838, by which time Reynolds was pragmatically no longer promoting on the basis of subterranean secrets.

Though the venture surveyed nearly 300 islands and more than 1500 miles of Antarctic shoreline, the entrance was not encountered. The expedition, however, marked a turning point for American science, and the Smithsonian Institution was established to archive the thousands of superterranean specimens collected.



"House of Representatives, *April 2d*, 1836.

"Mr. Pearce, of Rhode Island, from the Committee on Commerce, reported the following resolution:—

"*Resolved*, That the use of this Hall be granted to J. N. Reynolds, Esq., on Saturday evening next, for the purpose of delivering an address, on the subject of an Expedition, or Voyage of Discovery, to the South Sea and Pacific Ocean.

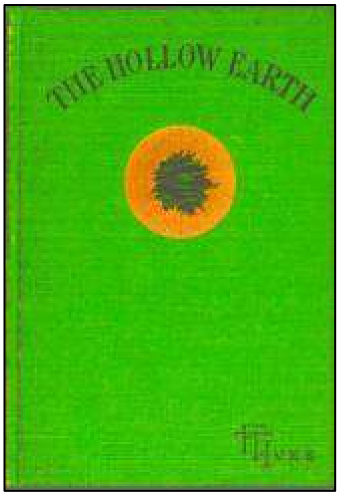
"The Resolution was agreed to."

From an awed Edgar Alen Poe, reviewing the address in the January 1837 Southern Literary Messenger,

> *With mental powers of the highest order, his* [Reynolds'] *indomitable energy is precisely of that character which will not admit of defeat.*

Poe used some 700 words of Reynolds' address in The Narrative of Arthur Gordon Pym, a work we'll review in Chapter 16, Underground Rivers in English Fiction.

In the October 1882 Harper's Magazine, a Mr. Howgate proposed an expedition to discover "Symmes' Hole." The team would acclimate to higher and higher latitudes, moving further north each year, watching for animals that wintered within the earth and emerged to bear young. The explorers were to follow the animals to where they re-entered.



Franklin Titus Ives, chairman of the Connecticut State Board of Mediation and Arbitration, was another proponent Symmes' theory. We'll quote a few passages from his The Hollow Earth (1904).

Arctic Elephants

> *It has often been a query from whence came the Arctic elephants, the remains of which are found so plentifully on the north shores of Siberia, some of which during the last century have been in such a state of preservation as that their flesh was eatable by bears and wolves.*
>
> *Why were they protected by a covering of hair if not originating in a colder climate than exists south of the Arctic Circle?*
>
> *Do they not still exist in the interior, or have they passed out with the great Auk, a former external resident?*

The Role of Centrifugal Force

> *Every lake is but a mammoth spring, or reservoir of numerous springs that feed into its base. The provision by nature of this inexhaustible reservoir of fresh water is beyond doubt the most essential of any other bounty bestowed upon every living thing on Earth's surface. The principle of centrifugal motion and power is here developed to its highest advantage.*

> *At this point it may be well to call attention to another feature in the river system. The water on the grindstone will give force to this suggestion. At a certain speed the water will tend to the outside of the stone; below speed required to do that, the tendency will be toward the center of the stone, or strictly toward the center of the Earth's motion.*
>
> *Now let us see what the river system says. Look on your maps and see about where the common divide occurs, which is seemingly not far from the 50th parallel, where centrifugal force is apparently not strong enough to carry the waters toward the Equator, and the principal waters flow toward Symmes's Hole.*
>
> *Look on your maps.*

The Insufficiency of Rainfall

> *And while all this grand and complete arrangement supplies vegetation with its bathing and drinking, as said before, it has nothing to do with the living and lasting supply of our springs, lakes and rivers. They are fed from a never failing and almost unchanging source -- that is, by the immense supply taken in at the polar holes in a river over 4,000 miles wide at each end of the Earth's axis.*

Mountaintop Springs

> *Within twenty rods of the top of Mount Washington, the highest peak in the New England States, flows out a copious spring of water. The whole mountain system is full of springs and lakes. The entire Adirondack region is in the same condition. It is safe to leave it to the reader who has ever been out of sight of the smoke of his own chimney to think of the abundance of instances where he has seen lakes and springs on the tops of high hills, where no shed water to any extent could reach them, and wonder how they came there.*

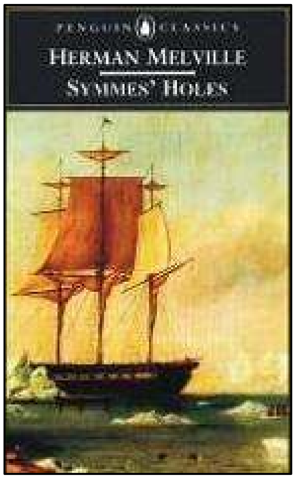
Artesian Wells on Plains

> *Here is a subject that is worthy the attention of settlers in our arid and apparently desert regions of country. We are told that the source of an artesian well is from fountains of water gathered and stored in higher lands that run through different strata of rocks till they reach the valleys, and when the boring reaches down to these strata the water naturally comes up toward the height of the fountain it started from. Would it not be a sensible inquiry to make as to where the supply came from to furnish the water in the higher lands? That the accepted theory of supply to artesian wells comes from some higher point is not correct can be demonstrated on the prairies, where no higher land is in sight.*

The Symmes legacy seems unbounded. The man wasn't the first to imagine polar holes, but he the popularized the possibility. In the century following his 1818 "TO ALL THE WORLD," scores of dime novels -- of which we've listed many -- followed one fictional hero or another into the polar entrance. Fortunately, most escaped.

Reynolds is also known for his May 1839 Knickerbocker Magazine piece, "Mocha Dick, or the White Whale of the Pacific" detailing the capture of a giant sperm whale infamous for attacking ships. The mammal was named after the Mocha Islands where it was sighted. "Dick" was a common male name. Herman Melville (1819-1891) plagiarized the theme in his 1851 novel.

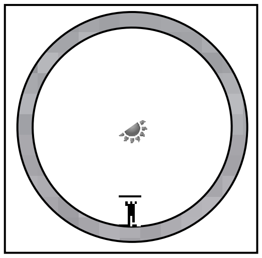
Melville, in turn, has been linked to hollow-earth lore by his manuscript Symmes' Holes (1876), a recent printing shown to the right. It may be a Penguin Classic, but unfortunately the work's a forgery.

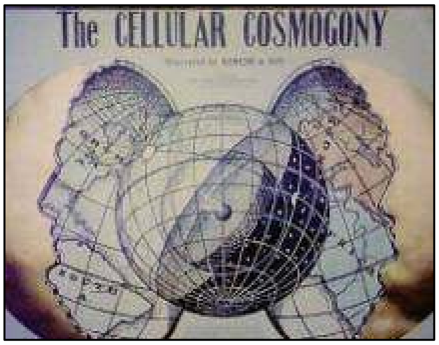


Henry David Thoreau (1817-1872) cited Symmes in Walden (1854).

> *It is not worth the while to go round the world to count the cats in Zanzibar. Yet do this even till you can do better, and you may perhaps find some "*Symmes*' Hole" by which to get at the inside at last.*

Cyrus Read Teed (1839 -1908), an "electro-alchemist" from Utica, New York, saw the "geocosmos" differently. According to Teed's Cellular Cosmogony (1870), the earth is a hollow sphere and we dwell on the inner side. Our heads point toward the center where the sun, half dark and half light, rotates to create the appearance of sunset and sunrise. "Gravic rays" emanating from the sun hold us onto the crust. The universe that we "see in the sky" is cradled "in the hands of God."





The earth shell consists of 17 layers of which the outermost seven are metallic, the golden layer having the greatest radius. The next five layers are mineral and the remaining are geologic strata.

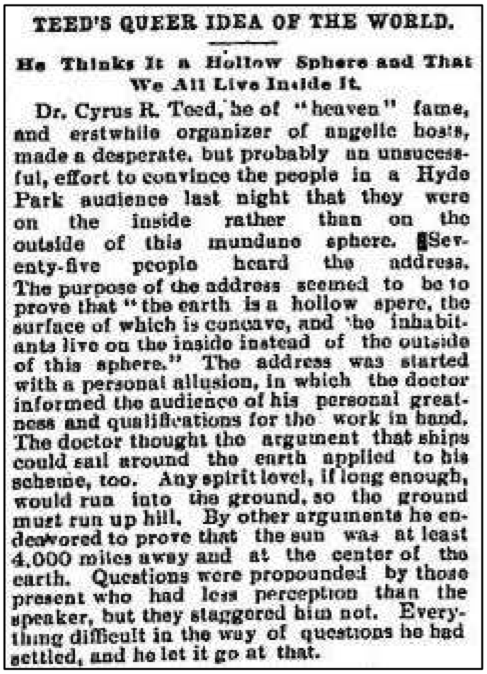
Within the earth shell are three atmosphere shells: air, hydrogen, and "aboron" which prevent us from seeing across.

In summary, "To know of the earth's concavity is to know God."

After an 1869 "illumination" in which it was revelation that he was the incarnation of Christ, Teed changed his name to Koresh, established "Koreshenity" and established a utopian commune Florida. Teed and followers organized the Koreshen Geodetic Survey and conducted an experiment to prove the earth's concavity.

Using a “rectilliniator,” the believers spent five months in 1897 moving the device along four miles of beach to prove the earth’s concavity. The results were said to be as Teed predicted.

At the right is the opinion the Chicago Daily Tribune, March 31, 1895.



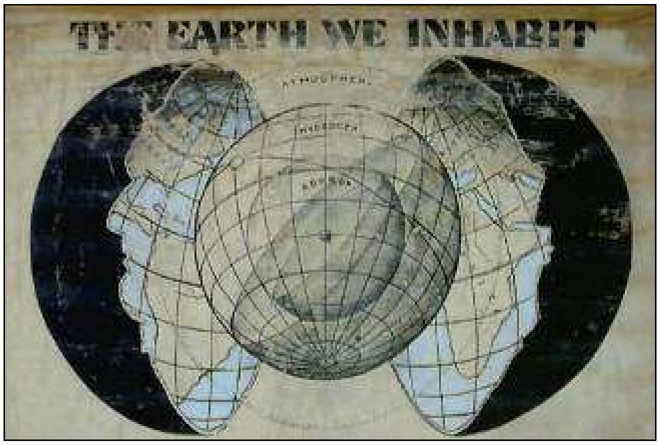
TEED'S QUEER IDEA OF THE WORLD.

He Thinks It a Hollow Sphere and That We All Live Inside It.

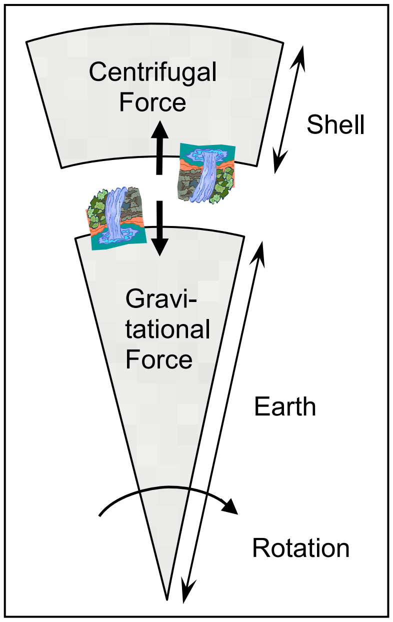
Dr. Cyrus R. Teed, he of "heaven" fame, and erstwhile organizer of angelic hosts, made a desperate, but probably an unsuccessful, effort to convince the people in a Hyde Park audience last night that they were on the inside rather than on the outside of this mundane sphere. Seventy-five people heard the address. The purpose of the address seemed to be to prove that "the earth is a hollow spere, the surface of which is concave, and the inhabitants live on the inside instead of the outside of this sphere." The address was started with a personal allusion, in which the doctor informed the audience of his personal greatness and qualifications for the work in hand. The doctor thought the argument that ships could sail around the earth applied to his scheme, too. Any spirit level, if long enough, would run into the ground, so the ground must run up hill. By other arguments he endeavored to prove that the sun was at least 4,000 miles away and at the center of the earth. Questions were propounded by those present who had less perception than the speaker, but they staggered him not. Everything difficult in the way of questions he had settled, and he let it go at that.

While Teed draws upon Symmes for hollow earth inspiration, there's a significant difference in perspective.

> According to Symmes, we're not within the hollow earth and thus can only speculate on the nature of that realm. Symmes proposed an American expedition of discovery.
>
> According to Teed, we're already living in the hollow earth and need to explain what we observe about us.



Teed's "illumination" provided an explanation. Centrifugal force -- the inertial force that pushes objects outward from the center of a spinning circle -- accounts for what the unenlightened -- Newton and his crew -- mistakenly attribute to gravity.



On the bottom if the diagram to the right we have the world as explained by Newton.

A segment of a solid rotating earth with a waterfall on its surface.

Gravitational force causing the water to fall downward. Gravitational force doesn't depend on the earth's rotation.

On the top we have Teed's explanation.

A segment of a spinning shell with an upside-down waterfall on its inner surface, "upside-down" on the page, that is, not to an inner-world citizen.

Centrifugal force pushing the waterfall outward.

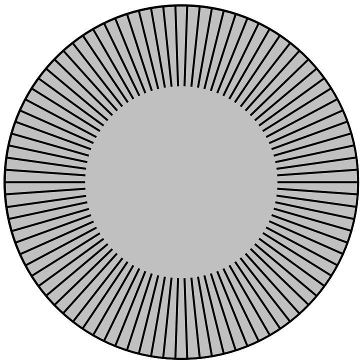
According to Teed, the waterfall we think to be directed by gravity is in fact responding to outward centrifugal force. It makes conceptual sense, perhaps, at least until we look at the math.

To begin, let's consider a non-rotating solid globe, Case 1 below, in which the only force operating is that of gravity,

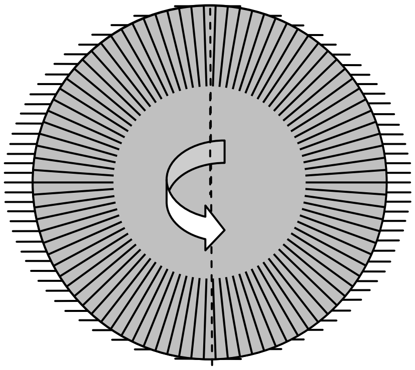
Gravitational force = $m\ g$

where m is an object's mass, and
g is the gravitational constant, 9.81 meters/second^2 at the earth's surface.

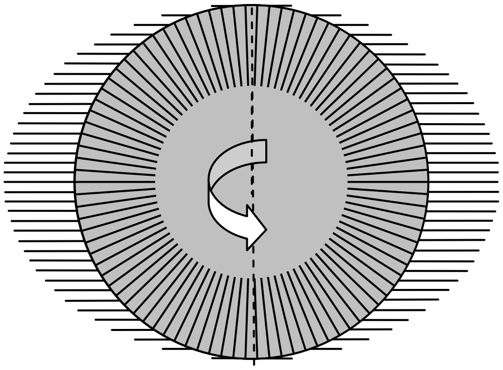
The radial lines represent gravitational pull toward the center of the globe. For a given object, the g's magnitude is the same everywhere on the surface.



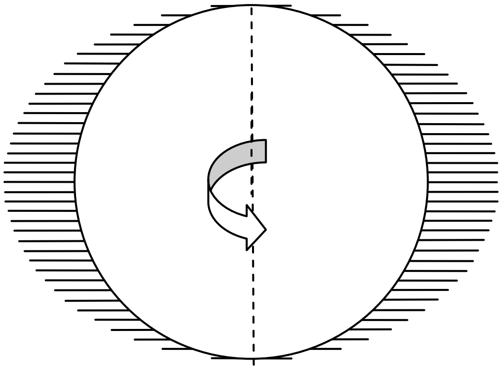
Case 1: Gravitation alone



Case 2: Gravitation plus 1 rotation/day centrifugal force



Case 3: Gravitation plus 17.1 rotation/day centrifugal force



Case 4: 17.1 rotation/day centrifugal force alone

Case 2 adds centrifugal force

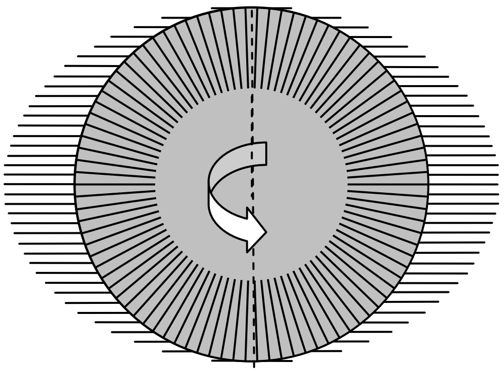
Centrifugal force = $m\, r\, \omega^2$

where r is the radius of rotation, 6371 kilometers for an object at the earth's equator, and
ω (omega) is the angular velocity, 1/day for the earth.

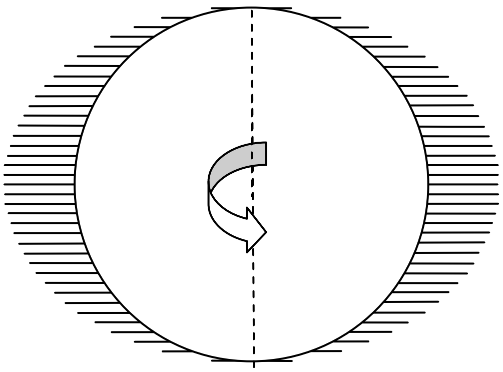
Centrifugal force is directed perpendicularly-outward from the axis. It is greatest at the equator and zero at the poles, because there, r is zero.

Other rotations about axes in different orientations and of differing angular velocities could be added -- spinning the spin, so to speak -- but regardless of how many spins are imposed, the sphere ends up rotating about but one resultant axis at some constant ω. It's just a tipped version of the same diagram with proportionally longer or shorter lines sideways to the axis.

We on earth are influenced by both gravitational and centrifugal force, but at a ω of 1 rotation/day, the centrifugal force on an object at the earth's surface varies from 1/300 of gravitational force at the equator to zero at the poles. (We've exaggerated the illustrated horizontal lines to make them apparent; plotted to scale, the longest of them would be but a line-width in length.) Thanks to the earth's spin, we weigh 3/10 of one percent less at the North Pole than we do at the equator, but we don't find it worth hauling our scales to the Arctic.



Case 3: Gravitation plus 17.1 rotation/day centrifugal force



Case 4: 17.1 rotation/day centrifugal force alone

Case 3 spins our earth 17.1 times/day -- a "day" by our current timepiece, that is, not the solar day in the faster-rotating world -- the ω required for centrifugal acceleration at the equator to be 9.81 meters/second^2, counterbalancing the inward gravitational force. Could we do this, objects would weight nothing at the equator. At the poles, however, gravity would be unopposed and they'd weigh the weights to which we're accustomed.

Case 4 is Teed's model, that of a hollow earth with centrifugal force pushing us against the shell's inside. What physics tells us -- though it may not be what we expect -- is that there's no gravitational attraction between a shell of any thickness and an object within. There is no gravitational pull whatsoever on objects within this world; there's just the centrifugal push that the rotation exerts.

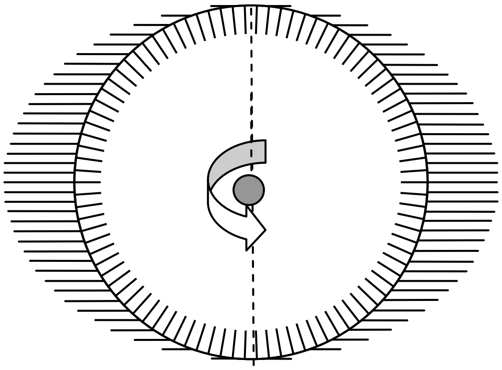
To make Teed's world function like the one we see, we need this centrifugal force to equal the gravitational force with which we are familiar. At a ω of 17.1 rotations/day, an object dropped at the interior world's equator travels straight toward the surface, accelerating at 9.81 meters/second^2, exactly as Teed would want.

At higher latitude, however, *r* is smaller. As centrifugal force is reduced, an object falls toward the shell more slowly than does an object dropped at the equator. Moreover, the path of descent is inclined to what the locals would call "down."

At the poles where there's no centrifugal force, objects in Teed's world don't fall. While few of us have been to either pole, we're quite certain that a dropped glove falls to the snow.

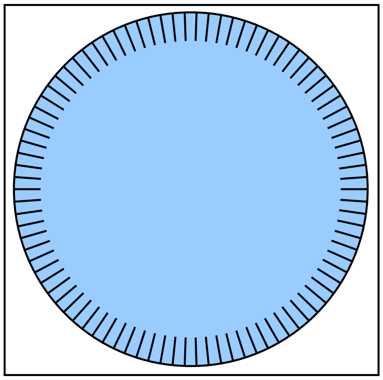
In Case 5, a miniature sun at the sphere's center exerts a thin ring of inward gravitational pull. An object loosened at the poles would obey the small sun's gravity and lift away from the shell's inner surface. Rotating the interior sun about a sister changes nothing but the gravitational magnitude. Add a pair of internal moons and we're approaching Seaborn's universe, but we're not helping our case.

Our conclusion: Centrifugal force cannot simultaneously maintain the same centrifugal force at every point on the shell, what's needed for falling objects to behave the same, independent of latitude.



Case 5: Gravitation plus 17.1 rotation/day centrifugal force

Such Newtonian quibbling would not have phased Symmes, however, as according to J. McBride's Symmes's Theory of Concentric Spheres; Demonstrating that the Earth Is Hollow, Habitable Within, and Widely Open about the Poles (1826), gravity is not an attractive force related to mass, but rather a pushing force (a pressure in modern terminology) exerted by a universal ether.

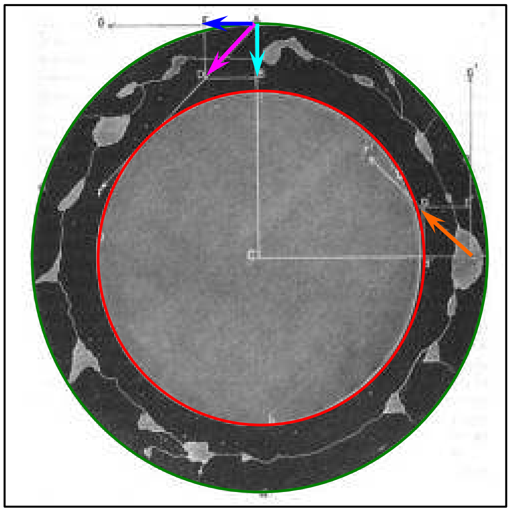


Case 6: The pressure of ehter

The hollow earth can be dismissed by any number of physical arguments, but our observation is suffice. Everywhere on the earth objects fall straight downward with the same acceleration. We can't say that we've proven the gravitational earth theory to be correct, but we can say that we've proven Teed's hollow earth theory to be incorrect.

Symmes and Teed were not alone, however, in their application of alternative physics to problems of fluid flow. Although the paper was written to establish why springs emit from outside-world -- as opposed to inside-world -- mountaintops -- the higer, the better, actually -- we see like confusion in "Why Do Springs and Wells Overflow?" Popular Science, November 1879, by Nelson W. Green.

Here's the essence of the proof with items colored to assist quick identification.



> *Let **aaa**, be a great circle of the earth attained by passing a plane through the earth's center C, perpendicular to its axis, and **bbb**, the circle cut by the same plane through the inner surface of the earth's supposed crust. In order to obtain room for the illustration, this section is exaggerated.*
>
> *Let the line **AB** represent the force of gravity, and **AE** the centrifugal force at the point A, which will operate in the direction of the tangent AG. These two forces, for the purposes of this discussion, may be assumed to be equal, as the question of their relative intensities does not enter into the problem.*
>
> *Erect upon the lone **AB** the square ABCD and draw the diagonal **AD** produced to F. By a well-known law we shall have **AD** representing the resultant of the forces of **AB** and **AE** -- that is, the line **AD** will represent the direction of AF, and the intensity of the resultant of the force of gravity and centrifugal force acting at the point A.*
>
> *It will be observed that since the diagonal of either square or of a parallelogram is longer than either of its sides, the resultant **AD** will have a greater intensity than gravity represented by **AB**.*
>
> *Now suppose the point A' to be some point inside the earth's crust, and some distance form the surface, and suppose that it is a particle of water in a body of water imprisoned by surrounding rocks. This particle will be acted upon by a continual impulse to move in the direction of A'F",*

> *with an intensity represented by **A'D'**. This will be true of every other water particle in the imprisoned body of water...*
>
> *Since the resultant has been shown to be greater in all circumstances than gravity, certainly the vast aggregations must also be greater than the aggregated gravity, and will be able to overcome it under all circumstances...*
>
> *The intensity of the centrifugal force will increase with the distance form the center of the earth, while gravity will decrease; the resultant will also increase. Thus we find the most abundant overflows at the tops of mountains or on high plateaus.*

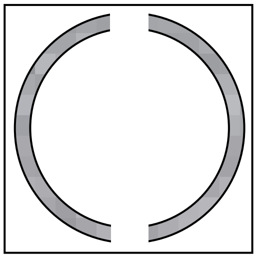
Green's physics isn't Newton's, as the former's centrifugal force is tangential, while the latter's is radial. But even if we overlook the 90-degree turn, Green's resultant ***AD*** (or **A'D'** if we move to the waterbody) is by inspection still not outward.

But back to our topic at hand, hollow globes.

Teed died before a German pilot Peter Bender came across Koreshen literature in a World War I prisoner-of-war camp. After armistice, Bender discarded the religious aspects to form the hollow earth doctrine, "Hohlweltlehre." Bender's writings led to the interests of the German Naval Research Institute for a method to locate enemy ships. A telescope pointed upward from Rügen Island in the Baltic failed to detect His Majesty's Navy, however, and the Germans lost the next war.

We will look a bit more at Teed's model in Chapter 26, Subterranean Water Bodies.

Like Symmes, William Reed (1830-1920) believed that sunlight shining into the polar openings would be sufficient to illuminate the interior and suggested that outer-crust folk colonize the inner earth. The reason the North Pole had not been yet discovered, Reed explained as a point of proof, is because it lies in the center of the opening.

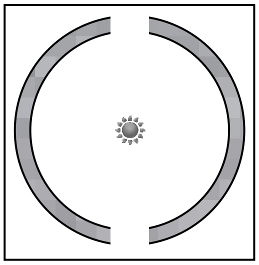


From Reed's Phantom of the Poles (1906),

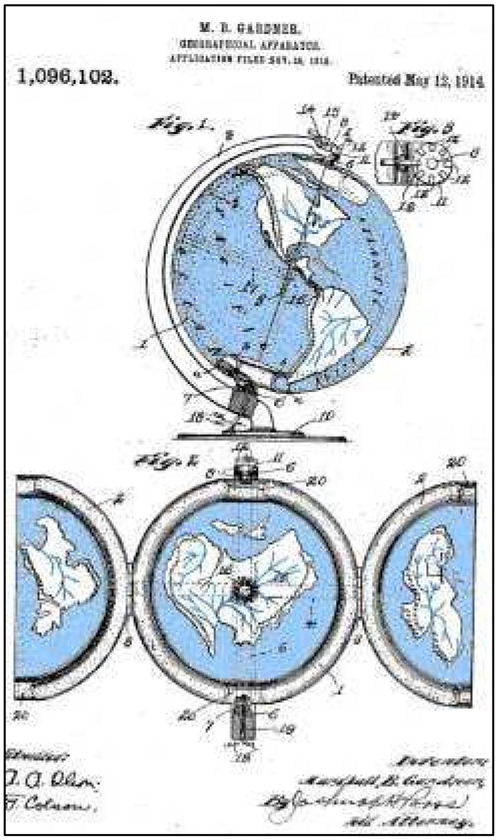
> *I am able to prove my theory that the earth is not only hollow, but suitable in its interior to sustain human life with as little discomfort as on its exterior, and can be made accessible to mankind with one-fourth the outlay of money, time and life that it costs to build the subway in New York City.*

Marshall B. Gardner (b. 1854), a maintenance man in a corset factory, wrote A Journey to the Earth's Interior or Have the Poles Really Been Discovered in 1913. The earth's crust is 800 miles thick and the interior sun is 600 miles in diameter.

> *Here, indeed, we may expect to find a new world, a world the surface of which is probably subdivided, like ours, into continents, oceans, seas, lakes, and rivers.*



Gardner cited the 1846 discovery of a woolly mammoth frozen in Siberia as evidence. Subscribing to the single-sun theory, Gardner suggested that the mammoth had wandered outside the hole at the North Pole and was frozen and carried to Siberia on an ice flow.



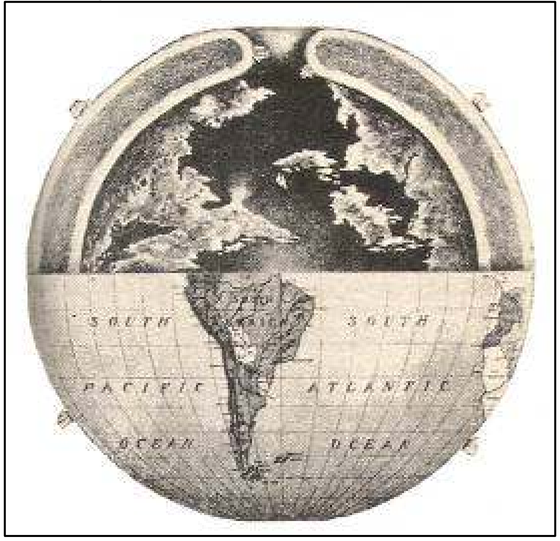
To the right is Gardnet's 1914 patent for a hinged model of our hollow earth.

> *Upon the outer surface of the globe are the usual geographical illustrations or maps indicating the continents of the world. Upon the inner surface of the globe are also arranged geographical indications indicating illustrating continents which according to the theory of the inventor exist on the inner surface of the globe.*

We've added the blue to make apparent the oceans and rivers.

As the patent is for a device -- not an idea -- its issuance was legally valid, but as the patent has since expired, we are free today to saw a globe in half and sktech the interior with what ever geography we favor.

The polar-hole arguments of Gardner and Reed are the same as Symmes'. Reed suggested that the flattening of the poles proves that there must be an opening, as this would detract from the roundness. As for how the central sun came to be, Gardner cited the Ring Nebula in the constellation Lyra which looks like shells of gas surrounding a star.



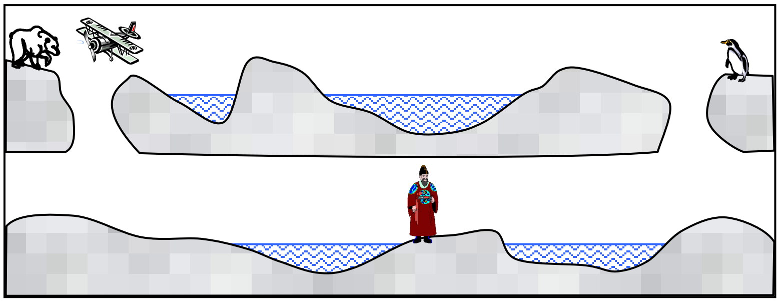
Both Reed and Gardner believed the earth's interior to be inhabited. Gardner believed it was the original home of both the Eskimos and all the East Asians, even suggesting that the "up and outward position" of Oriental eyes may be

> *A modification of the ordinary eye position induced by the fact that in the interior the sun is always in the zenith.*

Raymond W. Bernard, a Rosicrucian, dedicated The Hollow Earth (1964) to Admiral Richard Byrd.

> *The Greatest Geographical Discovery in History Made by Admiral Richard E. Byrd in the Mysterious Land Beyond the Poles.*
>
> *DEDICATED To the Future Explorers of the New World that exists beyond North and South Poles in the hollow interior of the Earth. Who will repeat Admiral Byrd's historic Flight for 1,700 Miles beyond the North Pole and that of his Expedition for 2,300 Miles beyond the South Pole, entering a New Unknown Territory not shown on any map, covering an immense land area whose total size is larger than North America, consisting of forests, mountains, lakes, vegetation and animal life.*

The King and Queen of the subterranean civilization Aghartha worry about atomic weapons, but allowed Byrd to enter because of his high moral character. We'll visit Aghartha again in Chapter 71, Sub-Saharan Streamflow and Shambhala.

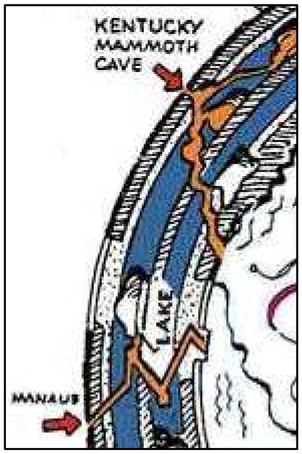


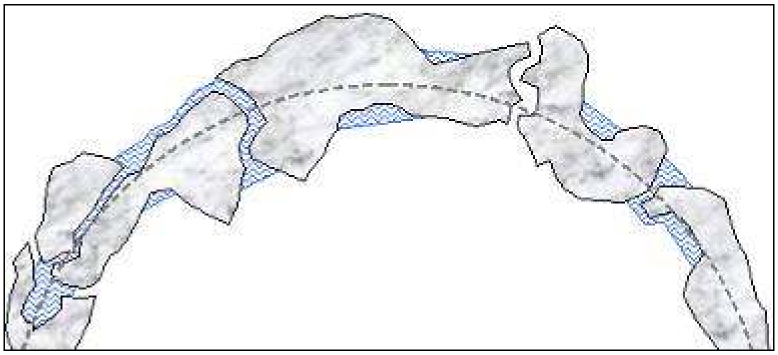
While Bernard marketed his work as non-fiction, there no longer existed Boys Clubs as gullible as those of a half-century prior.

Let's take a closer look at Bernard's cross-section. We see two tunnels to the earth's interior, one from Manaus, Brazil, the other from Mammoth Cave in the United States. We'll look at the karst geology of Mammoth Cave in Chapter 50. Note what the Brazilian route passes within the crust. A subterranean lake! Esoteric hydrology!

If caverns connect upper land surfaces to the fresh water reservoirs of the lower side, an artesian water well (a well in which the water level rises up the borehole) is explained by a deep lake on the bottom side.

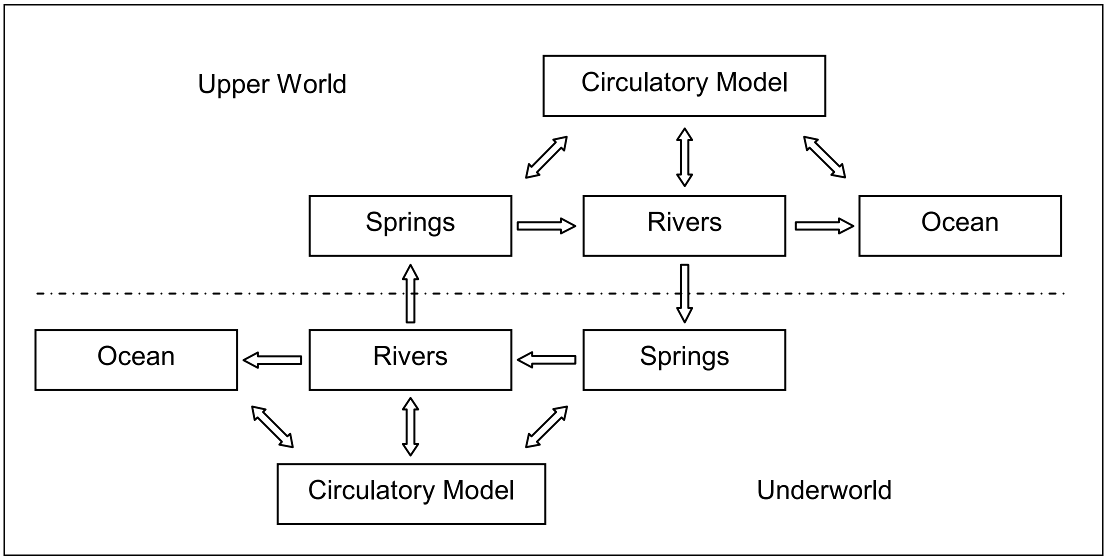
We create the figure below to illustrate a variety of hydrologic correspondences. On the left is an underground lake fed by an underground river. The spring feeding that river is fed by a lake on the underside. We've got a dry tunnel (safer than a polar maelstrom for human expeditions) and a few other water bodies for good measure.





Underworld hydrology is much like that of our own, just upside down to us. Inhabitants on either side would see the other as "underground."

To envision a unified hydrologic cycle, mirror an upside-down schematic beneath the one we know with River-Spring vertical links.

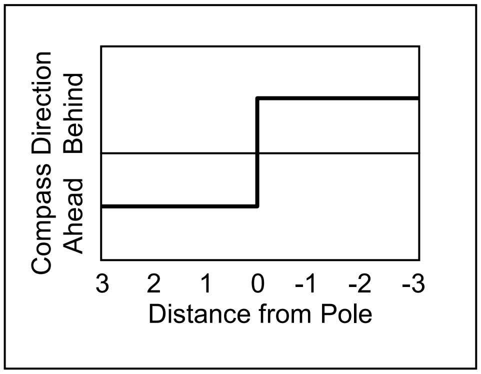

Upper World
Circulatory Model
Springs
Rivers
Ocean
Ocean
Rivers
Springs
Circulatory Model
Underworld

In our pursuit of our elusive underground rivers, we've passed though a potpourri of geophysical propositions. We might think that it was a lot of effort for not much result, but if we were among writers -- famous ones even -- we'd be substantially out-voted.

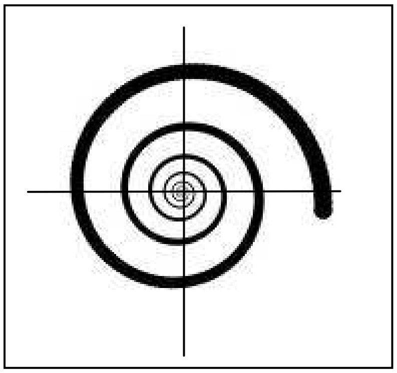
CHAPTER 15
THE MAELSTROM

Singularities

A mathematical "singularity" is a point at which a mathematical object fails to be well-behaved. If the mathematical object were the direction of a compass needle, it would point straight ahead as one walked toward the north magnetic pole, but flip when passing over that point. The pole is thus a magnetic singularity.



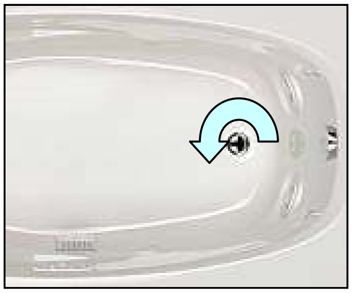
A whirlpool (a "vortex" in hydraulic jargon, a "maelstrom" in literature) represents another natural singularity. Conservation of angular momentum causes the water to spin faster and faster as the radius decreases. In crossing the center, the direction of flow shifts from right to left. The center represents a singularity.



Both singularities exist in the earth's polar region. One is indeed due to an underground river; the other is not. But which?

There are two general types of whirlpools -- those caused by water drawn down a drain and those caused by deflection. The millennia-old cultural association between underground rivers and whirlpools is largely due to not recognizing the difference.

A bathtub drain whirlpool is caused by a subsurface outflow. Absent another outside force such as the direction of the inflowing water, water will rotate counterclockwise north of the equator and clockwise south of the equator, the Coriolis effect named after Gaspard-Gustave Coriolis, who described it in 1835. Once this begins, centrifugal force drives the water to the outside and a cavity forms into which floating objects descend. The Coriolis effect is extremely slight, however, and the effect of almost anything will be greater, setting the whirlpool's direction.

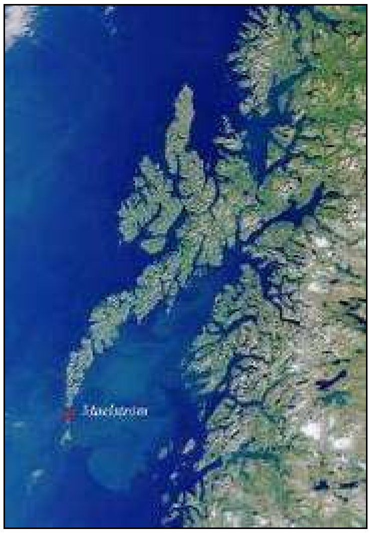


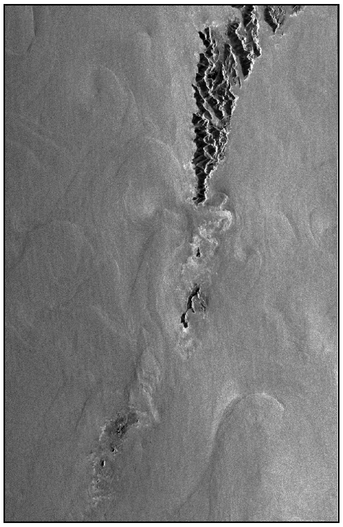
The most powerful "natural" whirlpools are the result of fast-flowing tidal waters through narrow and shallow straits. Unlike the bathtub, however, there is no lower outlet. A related phenomenon can be seen along a riverbank where a rock or fallen tree branch creates an eddy.

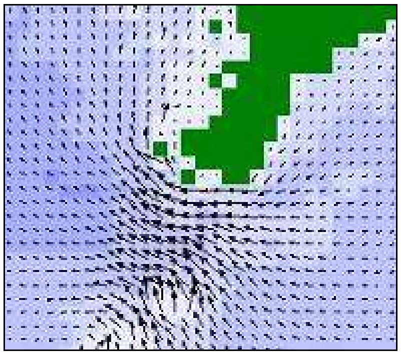
We will take a look at a particular maelstrom long the subject of speculation.

The Moskenstrom

An Arctic whirlpool, the Moskenstrom, can be observed at 67 degrees North, its cause being tidal currents between Norway's Lofoten Point and Vaeroy Island. The satellite photo reveals the complexity of ocean currents. The figure on the left is from a hydrodynamic computer model.







Animation of the tidal current

The Moskenstrom isn't a single funneling vortex, but rather a family of eddies, each at most 50 meters in diameter, no more than 1 meter in amplitude and persisting from a few minutes to an hour. The spread of disturbances can span 8 kilometers. The eddies rotate clockwise during the rising tide and counterclockwise during the falling tide.

Ocean fog spills over the Mosken mountains

A close-up

A combination of factors contributes to the Moskenstrom's creation.

About 370 million cubic meters of water are transferred through a narrow channel in 6 hours, creating currents of up to 22 knots.

The seabed gradient steeply rises from 500 to 20 meters.

The Moskenstrom faces the winds of the North Atlantic.

The current is most powerful when the tide is the greatest. Local lore that the vortex is at its strongest on Good Friday has reason, as the holy day is determined by lunar calendar.

It's a phenomenon that engenders tales.

The Tales

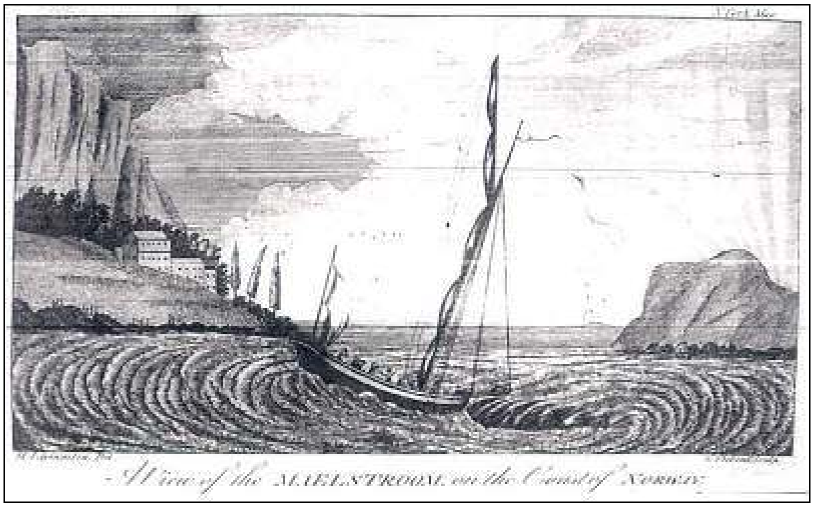
The Mariner's Chronicle: Containing Narratives of the Most Remarkable Disasters at Sea (1934) by Archibald Duncan cites accounts of this celebrated phenomenon.

M. Jonas Uamus describes the fate of ships, whales, bears and even nearby houses.

> *When it is flood the stream runs up the country between Lofoten and Moskoe with a boisterous rapidity, but the roar of its impetuous ebb to the sea is scarce equaled by the loudest and most dreadful cataracts: the noise being heard several leagues off, and the vortices or pits are of such an extent and depth that if a ship comes within its attraction it is inevitably absorbed and carried down to the bottom, and there beat to pieces against the rocks; and when the water relaxes, the fragments thereof are thrown up again. But these intervals of tranquility are only at the turn of the ebb and flood, and calm weather; and last but a quarter of an hour, its violence gradually returning. When the stream is most boisterous, and its fury heightened by a storm, it is dangerous to some within a Norway mile of it; boats, ships and yachts having been carried away by not guarding against it before they were within its reach. It likewise happens frequently that whales come too near the stream and are overpowered by its violence; and then it is impossible to describe their bowlings and bellowings in their fruitless struggles to disengage themselves.*
>
> *A bear once attempting to swim from Lofoten to Moskoe, with a design of preying upon the sheep at pasture in the island, afforded the like spectacle to the people; the stream caught him and bore him down, whilst he roared terribly, so as to be heard on shore. Large stocks of firs and pine trees, after being absorbed by the current, rise again, broken and torn to such a degree as if bristles grew on them. This plainly shows the bottom to consist of craggy rocks, among which they are whirled to and fro. This stream is regulated by the flux and reflux of the sea; it being constantly high and low water every six hours. In the year 1645, early in the morning of Sexagesima Sunday, it raged with such noise and impetuosity that on the island of Moskoe the very stones of the houses fell to the ground.*

An unnamed American captain provides a first-hand account. Note the "It is evidently a subterranean passage."

> *I had occasion some years since to navigate a ship from the North Cape to Drontheim, nearly all the way between the islands or rocks and the min... Two good seamen were placed at the helm, the mate on the quarter-deck, all hands at their station for working ship, and the pilot standing on the bowsprit between the night-heads. I went on the main topsail yard with a good glass. I had been seated but a few moments, when my ship entered the dish of the whirlpool. The velocity of the water altered her course three points toward the centre, although she was going three knots through the water. This alarmed me extremely for a moment. I thought destruction was inevitable... Imagine to yourselves an immense circle running round, of a diameter of one and a half miles, the velocity increasing as it approximated toward the centre, and gradually changing its dark blue color to white -- foaming, tumbling, rushing to its vortex, very much concave, as much so as the water in a tunnel when half run out; the noise too, hissing, roaring, dashing, all pressing on the mind at once, presented the most awful, grand, and solemn sight I ever experienced. We were near it about 18 minutes, and in sight of it two hours. It is evidently a subterranean passage. From its magnitude, I should not doubt that instant destruction would be the fate of a dozen of our largest ships, were they drawn in at the same moment. The pilot says that several vessels have been sucked down, and that whales have also been destroyed.*


View of the MAELSTROOM on the Coast of NORWAY

Historical Allusions

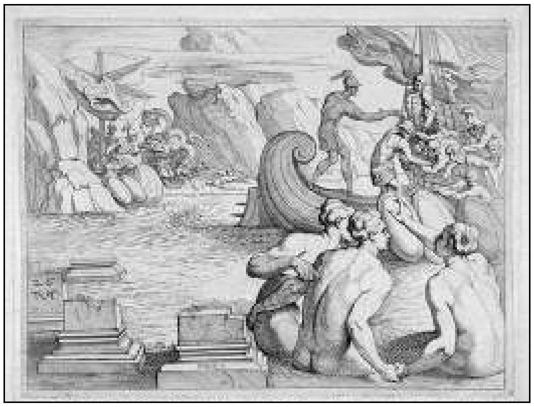
When in doubt about a legend's genesis, look to Homer.

> *You will see the other cliff lies lower, no more than an arrow's flight away. On this there grows a great leafy fig-tree; under it, awesome Kharybdis sucks the dark water down. Three times a day she belches it forth, three times in hideous fashion she swallows it down again. Pray not to be caught there when she swallows down.*
>
> *But when she sucked the sea-water in, one might look right down through the swirling eddy while the rock roared hideously around her and the sea-floor came to view, dark and sandy. Ashy terror seized on the crew. We had looked her way with the fear of death upon us; and at that moment Skylla snatched up from inside my ship the six of my crew who were the strongest of arm and sturdiest.*

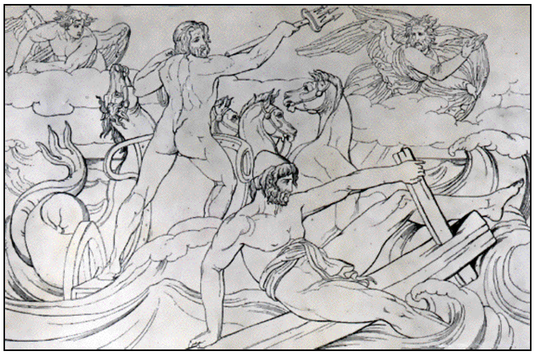
The Odyssey

> *Or when Ulysses on the larboard shunned*
> *Charybdis, and by the other Whirlpool steered.*

John Milton, Paradise Lost (1658)



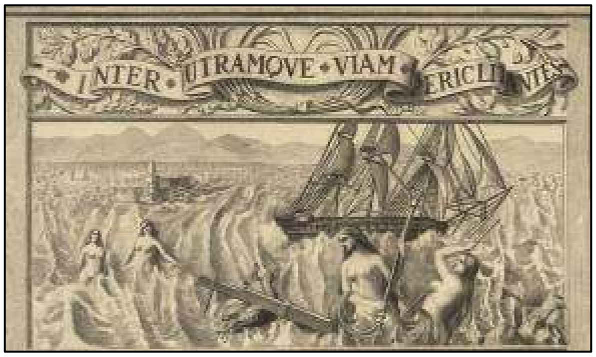
"Sirens, Scylla and Charybdis," a 17th-century etching by Theodor van Thulden.



Odysseus shipwrecked. After meeting Charybdis, nothing remained of his ship except the mast and the keel. Drawing by Bonaventura Genelli, 1798-1868.

> *As in the sea between Scylla and Charybdis the helmsman is ever in danger, yet he will be thought shrewd and sagacious, if, keeping his ship on a straight course between the two, avoiding the rocks on the one side and the maelstrom on the other, he brings his ship safely to harbour.*

Carlo Vitali, Dichiarazione dell'Impresa Generale della nuova Accademia Peloritana detta de' Pericolanti (1729)

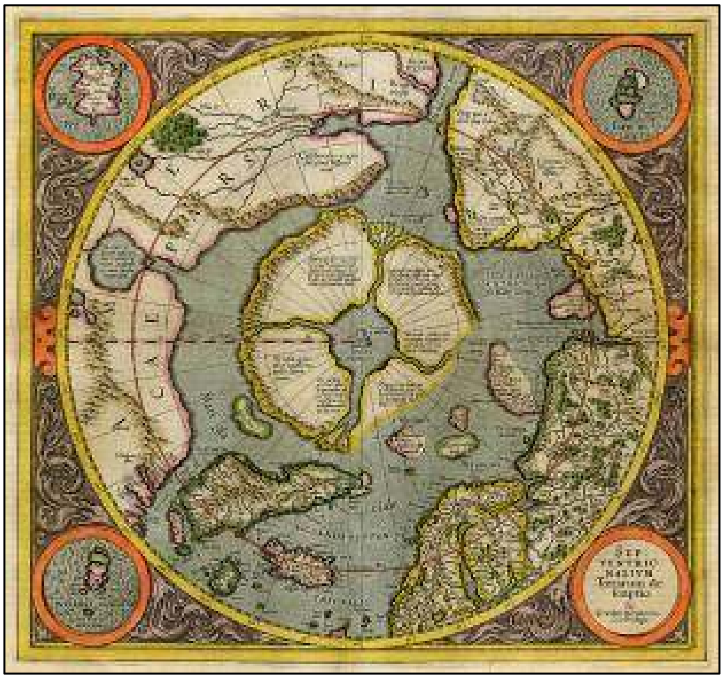

INTER • VTRAMQVE • VIAM • ERICLI NTES

Odysseus' encounter with Cyclops corresponds with an ancient Norse “kenningar” tale. Sorceress Circe's island, where there is a midnight sun and revolving dawns, speaks of northern latitudes. As the cacophony of Moskenstrom backwash on half-hidden rocks could deceive sailors that land is at hand, the Sirens could be Lofoten shoals made even more dangerous by fog and tide. South of Homer's Charybdis stands the island Thrinakia (“trident”). Mosken Island is three-tipped.

It indeed seems that a portion of Greek lore was drawn from locales far from Greece.

The eighth-century German, Paulus Warnefridi alluded to legend that there lies to the north a "very deep abyss of the waters which we call the ocean's navel. It is said twice a day to suck the waves into itself and spew them out again."

By the 16th century, the Moskenstrom was known to mapmakers.



Gerardus Mercator (1512-1594) made his livelihood as a craftsman of mathematical instruments and an engraver of brass plates. He is best remembered, however, as a mapmaker.

The Arctic map, the first ever of that region, was published a year after his death. At the center lies "Rupes nigra et altissima," a "very high black rock."

Why would such a rock be there?

As all seamen know, the needle of a compass is drawn by lodestone.

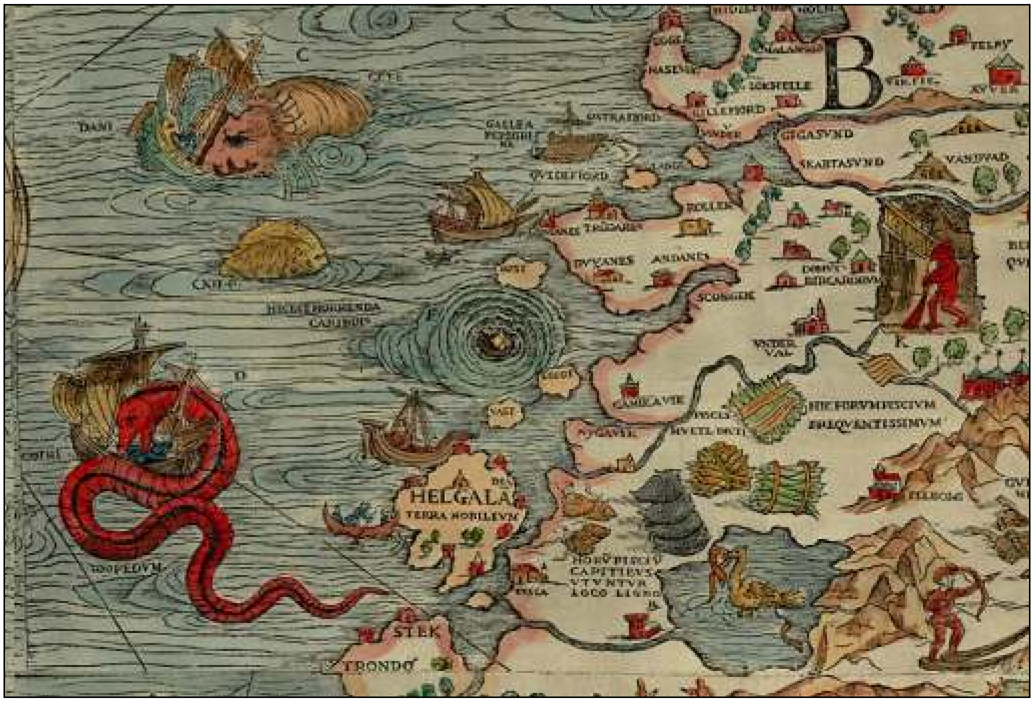
The map failed to show the Moskenstrom, but in a 1577 letter to English astrologer John Dee, the geographer placed both polar singularities -- the loadstone and the whirlpool -- at 90 degrees latitude.

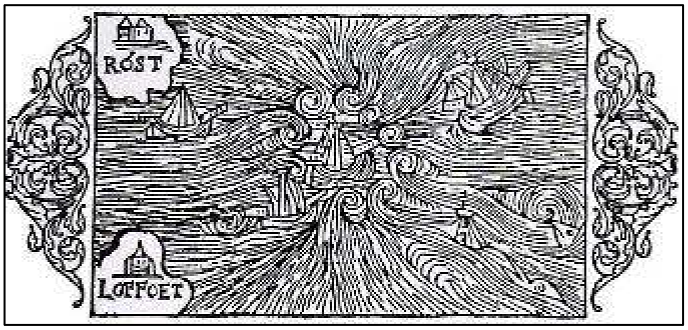
> *In the midst of the four countries is a Whirlpool... into which there empty these four indrawing Seas which divide the North. And the water rushes round and descends into the earth just as if one were pouring it through a filter funnel. It is four degrees wide on every side of the Pole,*

> *that is to say eight degrees altogether. Except that right under the Pole there lies a bare rock in the midst of the Sea. Its circumference is almost 33 French miles, and it is all of magnetic stone.*

The true magnetic pole is closer to Canada (labeled by Mercator as "California"). In Chapter 45, Subterranean Geophysics, we'll have more to say about this singularity.

The Carta Marin (1539), the earliest detailed Scandinavian map, was crafted by the Swedish ecclesiastic Olaus Magnus. Note the "Horrenda Caribdis," sea monsters and icebergs.

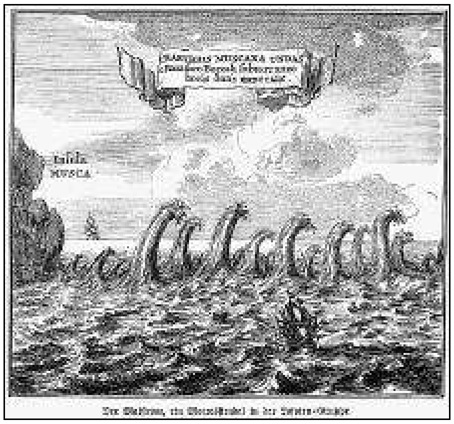




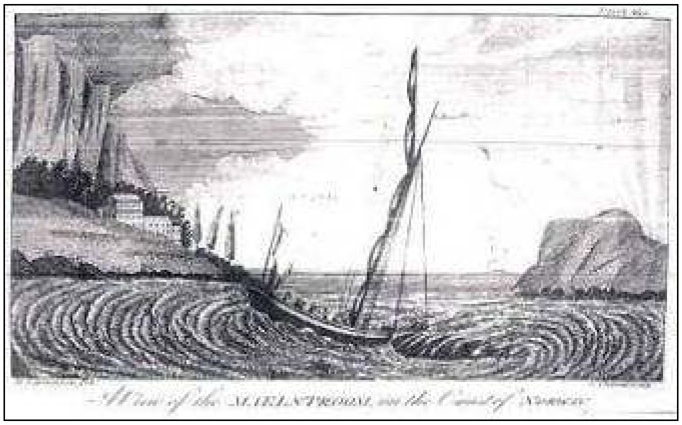
Magnus's depiction of the Moskenstrom in Historia de Gentibus Septentrionalibus (1555) is shown to the right. He attributed the vortex to divine forces and deemed it stronger than the previously-known Sicilian whirlpool Charybdis.

Norwegian priest Petter Das accurately described the Moskenstrom in The Trumpet of Nordland (c. 1685), attributing its strength to the phases of the moon, the current being strongest at the full and new phases. Unfortunately, Das wasn't translated into English.

Johannes Herbinius, the "Calvinist Copernicus," wrote his thesis on "waterfalls" in 1678.



Unattributed, 1678


A View of the MAELSTROM, on the Coast of Norway

Unattributed

An interesting topic, we may agree, but --we may wonder -- have oceanic whirlpools to do with underground rivers?

It took a great mind to deduce the tie.

Kircher's Meatus Subterraneus

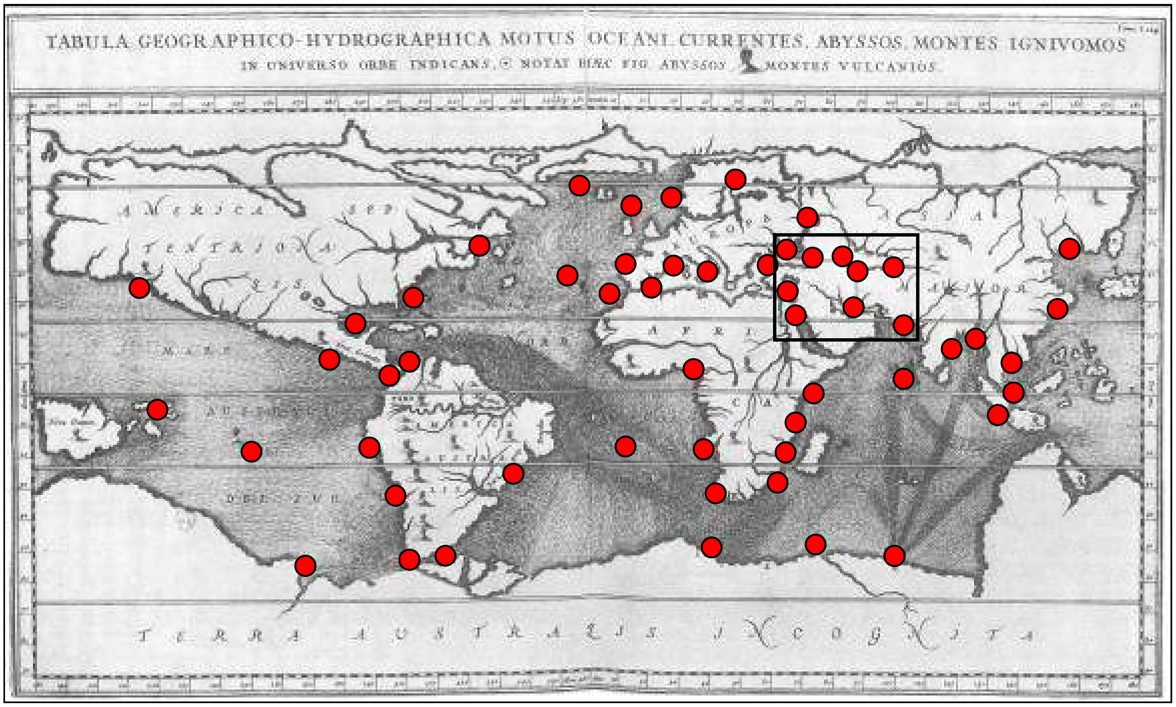
To the 17th-century polymath Athanasius Kircher, whom we met in Chapter 8, a whirlpool in the high sea would have seemed akin to the vortex observed when draining a cask. Ergo, there must be a hole in the floor of the sea.

The earliest chart of the global ocean circulation appeared in Kircher's Mundus Subterraneus (1665).

> *A great whirlpool at the North Pole sucks in the waters [of the sea] to a tunnel by which they are finally regurgitated at the South Pole.*

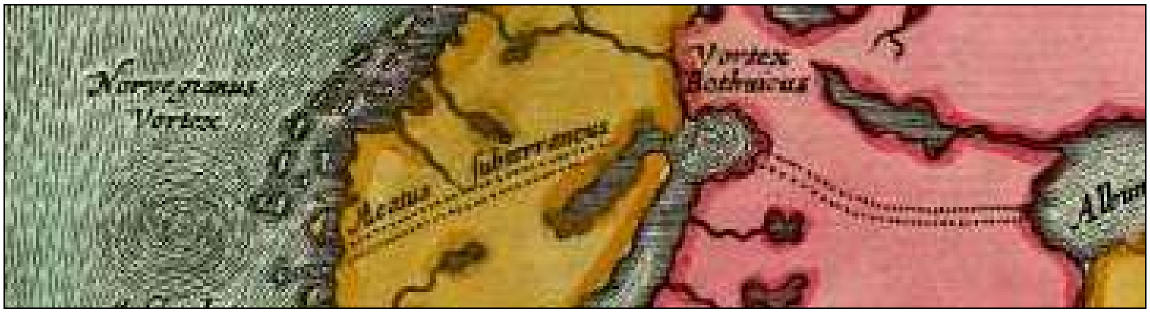
Holding to Aristotle's "primum mobile" the map charts the seas' the general westward flow. As to why particular currents should deviate from the ideal, Kircher turned to subterranean channels and cavities. The earth rhythmically sucks water into its interior near the North Pole (thus explaining the general pattern in the North Atlantic portion of his global map) and reissues it near the South Pole, mainly at three sites radiating into the Indian Ocean.

The map featured small markers -- enlarged below in red -- marking subterranean entrances and exits. Wherever an ocenanic perplexity arose, such a marker provided a solution. The pair of dots straddling the Isthmus of Panama, for example, facilitates the globe's general westward current, a belief dating to Plato.


TABULA GEOGRAPHICO-HYDROGRAPHICA MOTUS OCEANI CURRENTES, ABYSSOS, MONTES IGNIVOMOS
IN UNIVERSO ORBE INDICANS, ☉ NOTAT HIC FIG. ABYSSOS MONTES VULCANIOS
AMERICA SEPTENTRIONALIS
AMERICA
AFRICA
TERRA AUSTRALIS INCOGNITA

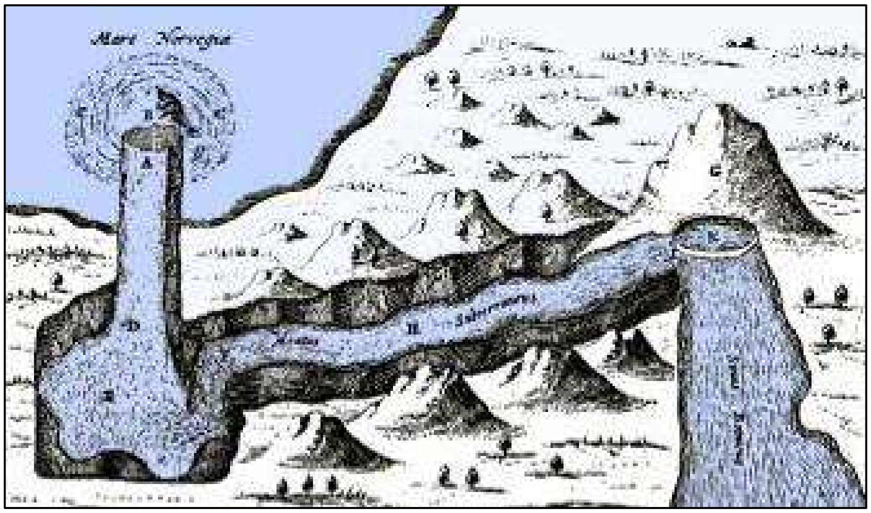
The box marks the Caspian Sea region, the subject of Chapter 69.

Mundus Subterraneus misplaced the Moskenstrom, but Kircher provided a more accurate location in other publications. Below is his portrayal of the Moskenstrom feeding a "Meatus Subterraneus," Latin for "burrow," to the interior.

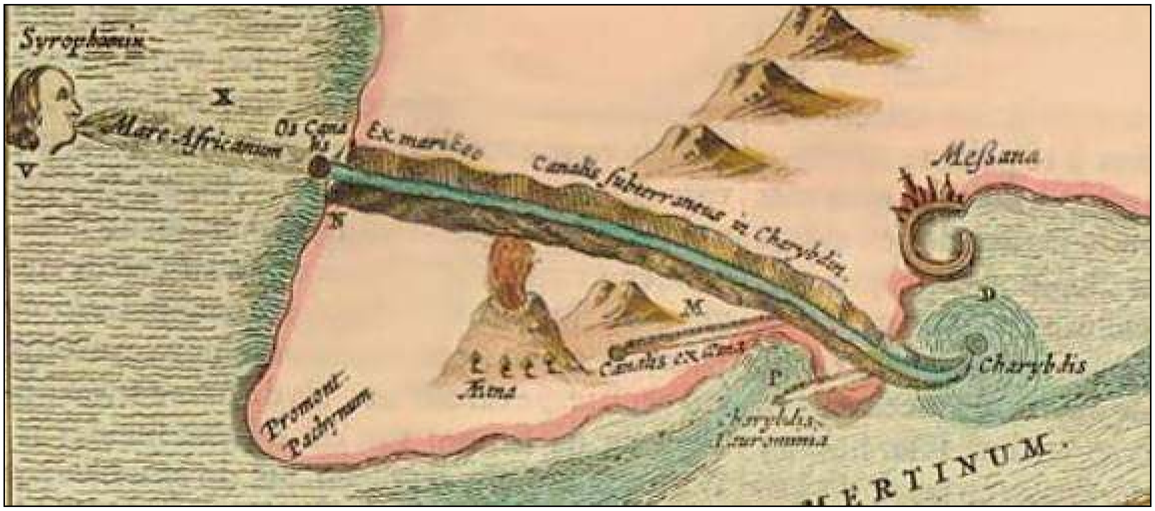

Norvegianus Vortex
Meatus subterraneus
Vortex Bothnicus

When the level of the Gulf of Bothnia is raised to a sufficient height, the current reverses and aided by flow through a subterranean tunnel from the White Sea, raises the tide on the Norwegian coast.

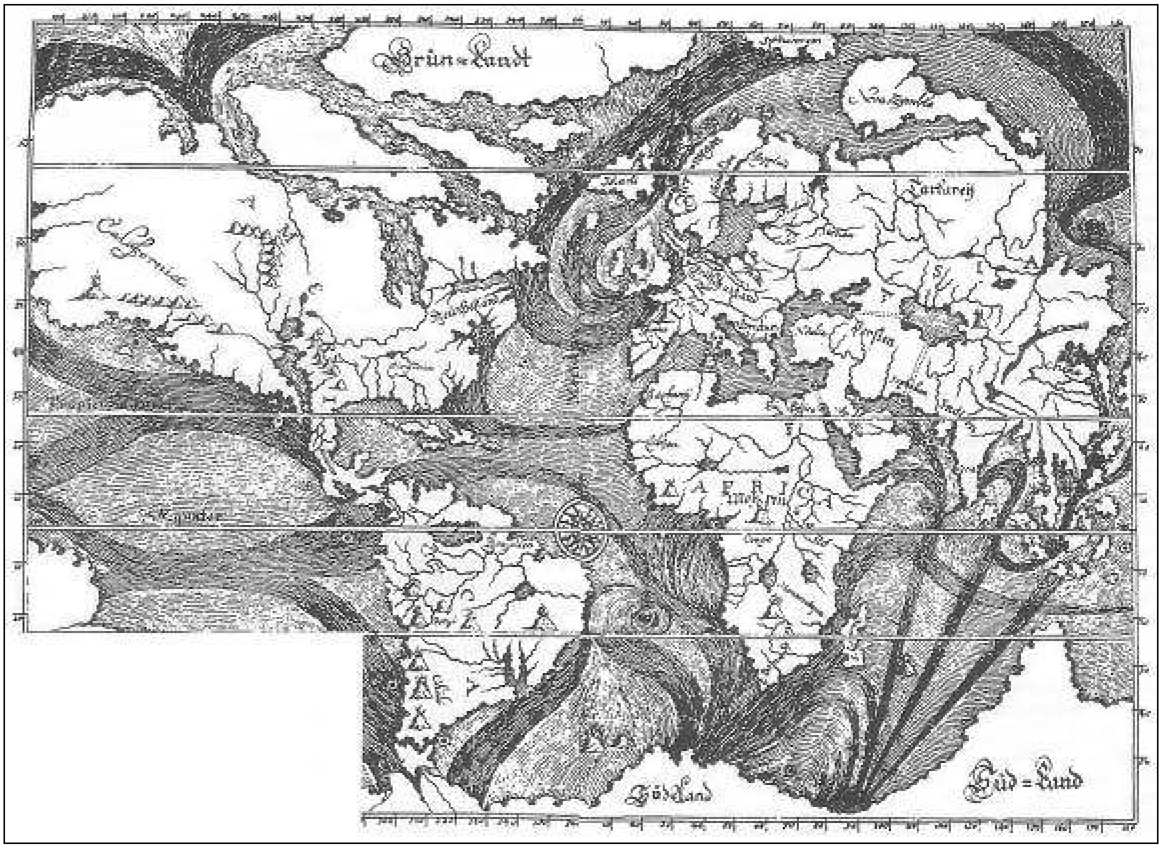
In the sketch to the right, the Moskenstrom ports to the Baltic, but there's no indication of an eastward extension.


Mare Norvegia
H
Subterraneus

Kircher's theory wasn't confined to points north. His map of the Stretto di Messina between Calabria and the island of Sicily depicts a "Canalis Subterraneus in Charybdis" having a lateral to -- or from, we can't be sure -- Mt. Etna.

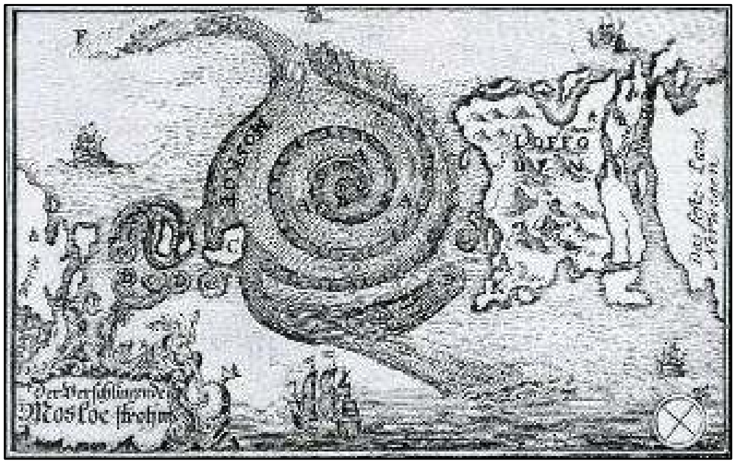

Syrophœnix
X
Mare Africanum
V
Os Canalis
N
Canalis subterraneus in Charybdin
Meßana
M
D
Charybdis
Canalis ex Ætna
P
Ætna
Promont. Pachynum
Charybdis Tauromnia
ERTINUM.

Below is Eberhard Happel's map of oceanis currents from Groste Denkwiirdigkeiten der Welt oder Sogenannte Relationes Curiosae (1685). Borrowing from Kircher, Happle assumed a vast reservoir beneath each polar region, imbibing water at certain hours and expelling it at others.

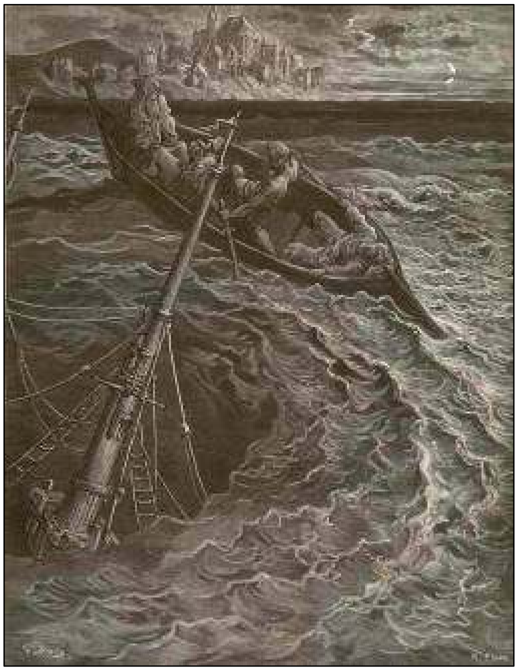

Grün = Landt
Tartarey
Süd = Land

Happle included a detail in the lower-left corner which we enlarge to the right.

It's the Moskenstrom.


Der Verſchlingende Mosloe ſtrohm

The etching to the right is Doré's illustration "The Whirl," for the 1876 edition of The Rime of the Ancient Mariner, not the Norwegian Maelstrom, we recognize, but worth including for three reasons:



The dramatic whirlpool.

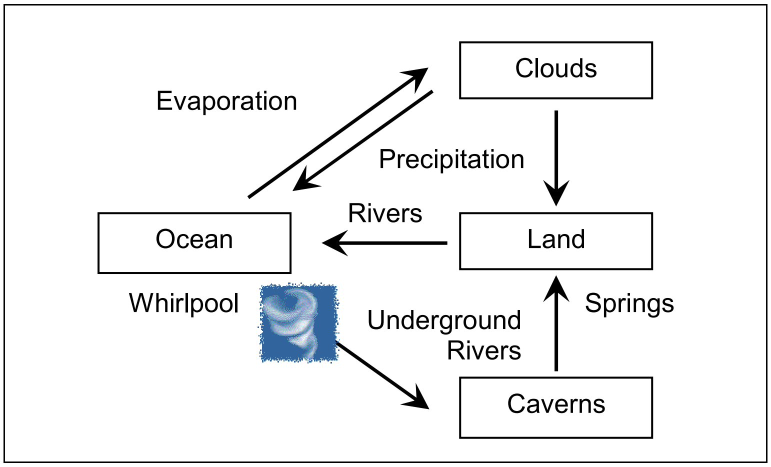
We encounter Doré's immediately-recognizable work elsewhere in our voyage, particularly in Chapter 33, Twenty-Five Centuries of Subterranean Portraits.

The Rime of the Ancient Mariner is by the poet Samuel Coleridge, author of "Kubla Kahn," the subject of Chapter 30, Down to a Sunless Sea.

It's an example of what so often we will find in our exploration of underground rivers. The tunnels intertwine.

The idea of water circulating deep within remained acceptable into the 18th century, as evidenced by Joseph Mead's An Essay on Currents at Sea (1758), and we will see in Chapter 27, Virtualizing the Imagined: Underground Rivers in Games, that such geography is yet with us.

Here's a schematic of how Kircher's "umbilicus maris" maintaining "a circulation like that of the blood in the human body" fits within a dual hydrologic cycle.



The Dual Hydrologic Cycle with Whirlpool

We earlier cited Moskenstrom lore from Duncan's The Mariner's Chronicle (1934). Duncan, however, was explicit in distancing himself from Kircher's subterranean hydrologic scheme.

> *The Maelstrom, a very dangerous whirlpool on the coast of Norway... Its violence and roarings exceed that of a cataract, being heard to a great distance, and without any intermission except a quarter every sixth hour, that is, at the turn of high and low water... This circumstance, among others, makes strongly against Kircher and others, who imagine that there is here an abyss penetrating the globe, and issuing in some very remote parts, which Kircher is so particular as to assign, for he names the gulf of Bothnia. But after the most exact researches which the circumstances will admit, this is but a conjecture without foundation: for this and three*

> *other vortices among the Ferroe islands, but smaller, have no other cause than the collision of waves, rising and falling at the flux and reflux, against a ridge of rocks and shelves which confine the water so that it precipitates itself like a cataract and thus the higher the flood rises the deeper must the fall be; and the natural result of this is a whirlpool or vortex, the prodigious suction whereof is sufficiently known by lesser experiments.*

The USS Nautilus glided under the polar ice in 1958 and found no downward opening. We can't be certain regarding the finding of the USS Thresher, we must allow, but that submarine's secret story must wait until Chapter 88, Extraterrestrials and Lost Races of the American West.

"Bottomless Pit Found on the Ocean's Floor," Far Out Magazine, April 1982, tells of an opening in the ocean floor between Panama and the Galapagos Islands, through which "scientists" say a constant flow of ocean water is being sucked beneath the marine floor.

It'd quite impossible to prove the absence of a hole.

Final Thoughts

We began this chapter with a question. Near the North Pole, there exist two singularities, the magnetic pole and the legendary Moskenstrom. Which is caused by an underground river?

For Kircher, the whirlpool was the doorway to below. He and his literary legacy -- Poe and his imitators whom we'll meet in 12-14 -- would have voted for the Moskenstrom.

But we now hold to a less-imaginative tidal explanation for the Norwegian seascape. The whirlpool is not of the bathtub drain variety. No water exits through the floor.

Kircher was wrong regarding the hydraulics, but his fanciful concept of the earth's fiery core was somewhat correct regarding the magnetic singularity. As we will see in Chapter 45, Subterranean Geophysics, there is indeed an underground river beneath us, one of molten iron, and that's compasses point the way the do.

As we're in the area, we should note Norway's Gronligrotta, the world's northernmost underground river. The karst springs have attracted tourists since the 16th century.

World Record

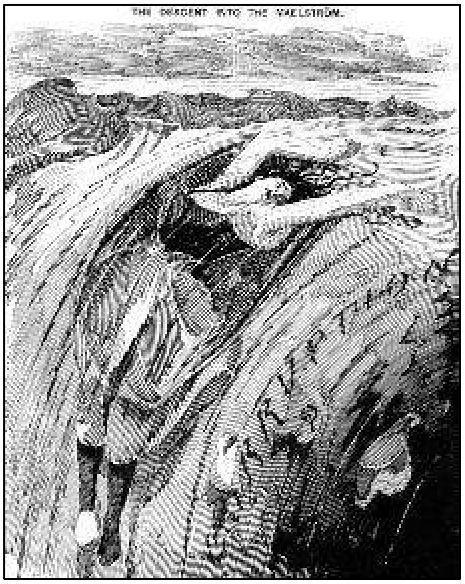
Most Northern
Underground River
66 degrees 25'

Gronligrotta
NOK 100.00

In Chapter 90, we'll pursue why it is that we believe things and observe that there's more that intellect involved.

There's drama in a whirlpool. The Punch cartoon of 1893 could not have been more vivid in its denouncement of corruption.

And when it comes to hydrology, a bit of drama helps sell the presence of underground rivers.


THE DESCENT INTO THE MAELSTRÖM.

CHAPTER 16

UNDERGROUND RIVERS IN ENGLISH FICTION

In the telling of stories, we sail upon underground rivers. Writers who incorporate subterranean waters into their settings contribute to our collective imagination.

In Chapter 14, we reviewed pseudoscientific speculation regarding a hollow-earth. As the geophysical assumptions never passed the muster of scientific scrutiny, however, let us consider not the facts, but rather -- Hello again, Plato -- the ideals.

When asked about literary meaning, T.S. Elliot (1888-1965) reflected,

> *At what point in its course does the Mississippi become what the Mississippi means?*

Or as we might revise it, pursuant to our particular journey,

> *At what point in its course does an underground river become what an underground river means?*

Is it when the underground river meanders our imagination?

Before us lie ten chapters concerned with underground rivers in fiction. Ten chapters may seem to be overkill, we agree, but there are many shelves of such literature.

We'll not belabor the arching question as we march through our library, but we'll return to it at the end.

What commonalities of literary device do we detect in our bibliographic sojourn?

We we to advise a novice author on proven ways to incoprporate an underground river in a work of fiction, what would we point to?

While we could test hypotheses by tallying works, we'll not be that academic. We'll just meander through the bookshelves, skimming what catches our fancy. At the end, we'll reflect on our subjective impressions.

In this and the next chapter, we'll look at authors aclaimed in English literature; in the chapter after, we'll look at some who wrote other languages. In the three chapters following, we'll meet writers who aimed at the quintessencial readership of underground river fiction, the Boys Club.. In the interest of brevity and with our apologies to the authors, the excerpts are pared to quotations related to subterranean waters.

William Shakespeare (1564-1616)

Though no works of the Bard refer to underground rivers, per se, Shakespeare indeed mentions Charon in his less-remembered Troilus and Cressida (1602) through the mouth of Troilus,

> *No, Pandarus, I stalk about her door,*
> *Like a strange soul upon the Stygian banks*
> *Staying for waftage. O, be thou my Charon,*
> *And give me swift transportance to those fields (Act 3, Scene II)*

UNITED STATES
SHAKESPEARE
1564-1964
5

Perhaps when Hamlet says in Act 1,

> *There are more things in heaven and earth, Horatio,*
> *Than are dreamt of in your philosophy.*

He intended to say,

There are more streams under the earth, Horatio,
Than are dreamt of in your philosophy.

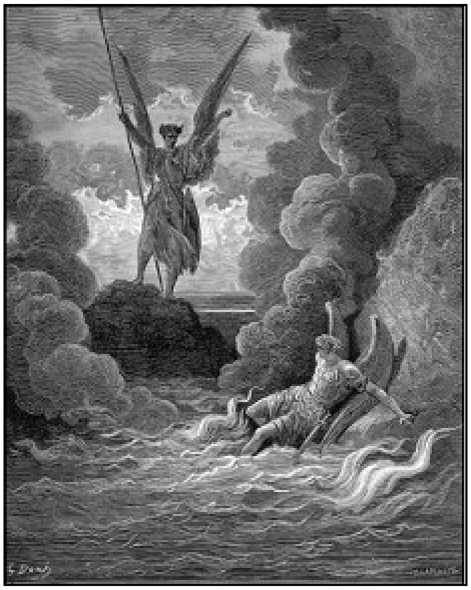
Ben Jonson (1572-1637)

Ben Johnson likewise didn't write of subterranean waters, but he'd no right to daylight the boatman. From Catiline (1611),

The rugged Charon fainted,
And asked a navy, rather than a boat,
To ferry over the sad world that came.

John Milton (1608-1674)

88
JOHN MILTON
1667 PARADISE LOST



In Milton's Paradise Lost (1658), the archangel Lucifer rebels against the Almighty and is hurled over the ramparts of Heaven and down through Chaos "nine times the space that measures day and night" to the vaults of Hell, where,

Of four infernal Rivers that disgorge
Into the burning Lake thir baleful streams;
Abhorred Styx the flood of deadly hate,
Sad Acheron of sorrow, black and deep;
Cocytus, nam'd of lamentation loud
Heard on the ruful stream; fierce Phlegeton
Whose waves of torrent fire inflame with rage.
Farr off from these a slow and silent stream,
Lethe the River of Oblivion roules
Her watrie Labyrinth, whereof who drinks,
Forthwith his former state and being forgets,
Forgets both joy and grief, pleasure and pain.

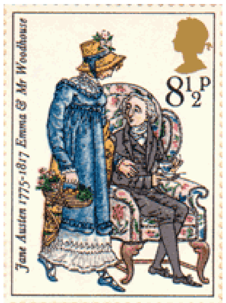
The illustration is Gustave Doré's etching, "Satan Rising from the Burning Lake."

As Adam and Eve dwell joyously in Paradise, Lucifer ascends into Eden by means of an underground river, disguising himself as a serpent and presenting the apple. What could worse be recorded about an underground river than that it brought us sin?

Jane Austen (1775-1817)

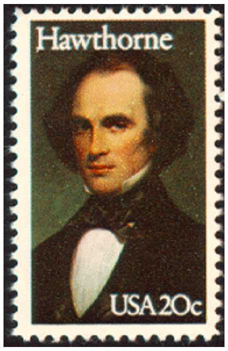
In Frederic & Elfrida (c. 1792), the teenage Austen is exuberant in the sentimental conventions of her day.

> *On her return to Crankhumdunberry (of which sweet village her father was Rector), Charlotte was received with the greatest Joy by Frederic & Elfrida, who, after pressing her alternately to their Bosoms, proposed to her to take a walk in a Grove of Poplars which led from the Parsonage to a verdant Lawn enamelled with a variety of variegated flowers & watered by a purling Stream, brought from the Valley of Tempé by a passage under ground.*


Jane Austen 1775-1817 Emma & Mr Woodhouse
8½P

Nathaniel Hawthorne (1804-1864)

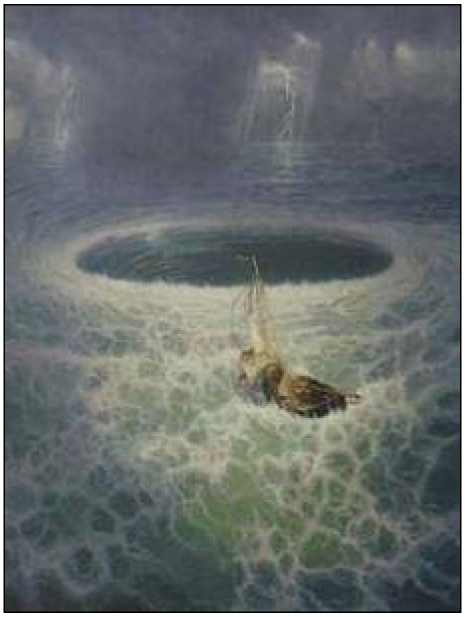
And for the morbid, consder Hawthorne's chapter "On the Edge of a Precipice," The Marble Faun (1860),



> *"Doubtless, too," resumed the sculptor (for his imagination was greatly excited by the idea of this wondrous chasm), "all the blood that the Romans shed, whether on battlefields, or in the Coliseum, or on the cross, -- in whatever public or private murder, -- ran into this fatal gulf, and formed a mighty subterranean lake of gore, right beneath our feet. The blood from the thirty wounds in Caesar's breast flowed hitherward, and that pure little rivulet from Virginia's bosom, too! Virginia, beyond all question, was stabbed by her father, precisely where we are standing."*

Edgar Allan Poe (1809-1849)

UNITED STATES POSTAGE
3 CENTS
CENTS 3
EDGAR ALLAN POE



One the greatest and surely the unhappiest of American authors, Poe married his 13-year-old cousin Virginia and strove to publish his writings. But as his works gained notice -- Poe was the first American author to be widely read outside the United States -- Virginia died of tuberculosis and Poe became increasingly depressed and erratic. In 1849 Poe disappeared in Baltimore and was found five days later, intoxicated and near death near the river front. He died four days later.

Poe's fiction dealt with paranoia, obsessions, death, feverish fantasies, the cosmos as source of both horror and inspiration.

The helpless passenger gazing in agony from the deck of his doomed ship at the approaching fate -- what could be more to Poe's taste than a howling maelstrom? MS. Found in a Bottle (1833) is the curiously-long message scribbled by the passenger prior to being sucked under.

> *But little time will be left me to ponder upon my destiny -- the circles rapidly grow small -- we are plunging madly within the grasp of the whirlpool -- and amid a roaring, and bellowing, and thundering of ocean and of tempest, the ship is quivering, oh God! and -- going down.*

Poe pursues his fascination with whirlpools in Descent into the Maelstrom (1841), citing the 1823 Encyclopedia Britannica for historical and geographical reality, but this maelstrom was many times the size of the Norwegian Moskenstrom of Chapter 15. Poe's maelstrom, as seen from the mountain,

> *Suddenly -- very suddenly -- this assumed a distinct and definite existence, in a circle of more than half a mile in diameter. The edge of the whirl was represented by a broad belt of gleaming spray; but no particle of this slipped into the mouth of the terrific funnel, whose interior, as far as the eye could fathom it, was a smooth, shining, and jet-black wall of water, inclined to the horizon at an angle of some forty-five degrees, speeding dizzily round and round with a swaying and sweltering motion, and sending forth to the winds an appalling voice, half shriek, half roar, such as not even the mighty cataract of Niagara ever lifts up in its agony to Heaven.*

And as seen from within,

> *The current acquired a monstrous velocity. The vast bed of the waters, seamed and scarred into a thousand conflicting, channels, burst suddenly into frenzied convulsions—heaving, boiling, hissing -- gyrating in gigantic and innumerable vortices, and all whirling and plunging on to the eastward with a rapidity water never elsewhere assumes, except in precipitous descents. In a few minutes more there came over the scene another radical alteration... The gyratory motions of the subsided vortices seemed to form the germ of another more vast.*

The narrator refers to the whirlpool as a "Phlegethon," one of the rivers in the Greek underworld, and recalls Athanasius Kircher’s claim that,

> *In the centre of the channel of the Maelstrom is an abyss penetrating the globe, and issuing in some very remote part -- the Gulf of Bothnia being somewhat decidedly named in one instance.*

That instance being Kircher, as per the pan-Scandinavian map of Chapter 15.

Poe even includes some applied physics,

> *I made, also, three important observations. The first was, that as a general rule, the larger the bodies were, the more rapid their descent; -- the second, that, between two masses of equal extent, the one spherical, and the other of any other shape, the superiority in speed of descent was with the sphere; -- the third, that, between two masses of equal size, the one cylindrical, and the other of any other shape, the cylinder was absorbed the more slowly.*

The observations provide the narrator an escape scheme -- cling to an empty cask -- allowing his tale to be written.

Although Poe called Kircher's views regarding the Maelstrom as "idle," he admitted that upon viewing the Norwegian vortex, Kircher's explanation "was the one to which, as I gazed, my imagination most readily assented."

The Narrative of Arthur Gordon Pym (1850), Poe's longest tale, is a dramatization of the beliefs of John Cleves Symmes (Chapter 14), the hollow-earth proponent whom Poe would have read in his youth.

“My name is Arthur Gordon Pym” is less gripping than Herman Melville's “Call me Ishmael,” but Poe's narrative does involve disaster in the South Pacific. Pym’s schooner is in the pack-ice where (due to Poe’s misinformation of Antarctic fauna) the explorers encounter a “gigantic creature of the race of the Arctic bear.”

Sailing further south, Pym's vessel encounters warmer weather and lands upon a wooded island where treacherous savages lead them to a chasm inland which descends into the bowels of the earth. Excerpts of Pym’s diary entries catch the gist of the sojourn.

> *March 9 -- The range of vapour to the southward had arisen prodigiously in the horizon, and began to assume more distinctness of form. I can liken it to nothing but a limitless cataract, rolling silently into the sea from some immense and far-distant rampart in the heaven. The gigantic curtain ranged along the whole extent of the southern horizon. It emitted no sound.*
>
> *March 21 -- The summit of the cataract was utterly lost in the dimness and the distance. Yet we were evidently approaching it with a hideous velocity. At intervals there were visible in it wide, yawning, but momentary rents, and from out these rents, within which was a chaos of flitting and indistinct images, there came rushing and mighty, but soundless winds, tearing up the enkindled ocean in their course.*
>
> *March 22 -- The darkness had materially increased, relieved only by the glare of the water thrown back from the white curtain before us. Many gigantic and pallidly white birds flew continuously now from beyond the veil, and their scream was the eternal Tekeli-li! as they retreated from our vision... And now we rushed into the embraces of the cataract, where a chasm threw itself open to receive us. But there arose in our pathway a shrouded human figure, very far larger in its proportions than any dweller among men. And the hue of the skin of the figure was of the perfect whiteness of the snow.*

The white curtain. The white birds. A white human figure. Nothingness.

There is no March 23 entry, and Pym leaves untold how he came to write his memoir.

In the January 1837 Southern Literary Messenger, Poe reviewed the Congressional address by Symmes' devotee, Jeremiah Reynolds, discussed in the previous chapter.

> *He has seen his measures adopted in the teeth of opposition, and his comprehensive views thoroughly confirmed in spite of cant, prejudice, ignorance and unbelief… With mental powers of the highest order, his indomitable energy is precisely of that character which will not admit of defeat.*

Poe used some 700 words of Reynold's speech in Pym.

In all three tales, Poe leaves unwritten what lies below the whirlpool; there's terror enough in the approach. And, as we will see in the chapter to follow, grist enough for many lesser mills.

Charles Dickens (1812-1870)

We'll get to the Dickensonian underground rivers of 19th-century London in Chapter 73, The Sinking of the Fleet.

A TRIBUTE TO GENIUS
1812
1912

J.W. De Forest (1826-1906)

There is a body of serious fiction that's lost in the libraries -- perhaps for good reason -- but when it comes to underground rivers, is thunderous English. We'll cite just one, De Forest's "Overland," The Galaxy, February 1871.

> *Isolated turrets, domes, and pinnacles came out in gleaming relief against the dark-blue background of the heavens. The opposite crests of the canyon shown with broad illumination. All the uncouth demons and monsters of the rock awoke, glaring and blinking, to menace the voyagers in the depth below. The contrast between this supereminent brilliancy and the sullen obscurity of the subterranean river made the latter seem more than ever like the Styx or Acheron.*

Literary overkill, but it would have worked a century ago.

Lewis Carroll (Charles L. Dodgson, 1832-1898)

The Wonderland
Postage-Stamp Case

Alice's Adventures under Ground
Lewis Carroll

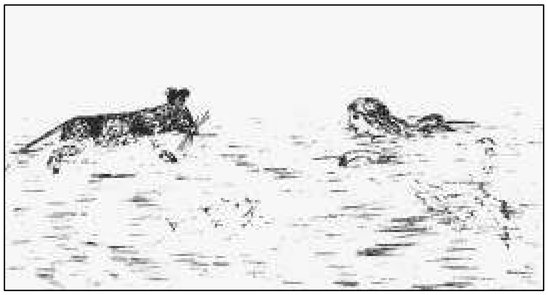
ALICE'S ADVENTURES IN WONDERLAND •

What Carroll first entitled Alice's Adventures under Ground came to be what we know as Alice's Adventures in Wonderland (1865). We'll pursue the challenge of tunnels through the globe in Chapter 26, Subterranean Water Bodies, one of many perplexities for our young friend.

> *"I wonder if I shall fall right through the earth! How funny it'll be to come out among the people that walk with their heads downwards! But I shall have to ask them what the name of the country is, you know. Please, Ma'am, is this New Zealand or Australia?" -- and she tried to curtsey as she spoke (fancy curtseying as you're falling through the air! do you think you could manage it?) "and what an ignorant little girl she'll think me for asking! No, it'll never do to ask: perhaps I shall see it written up somewhere."*

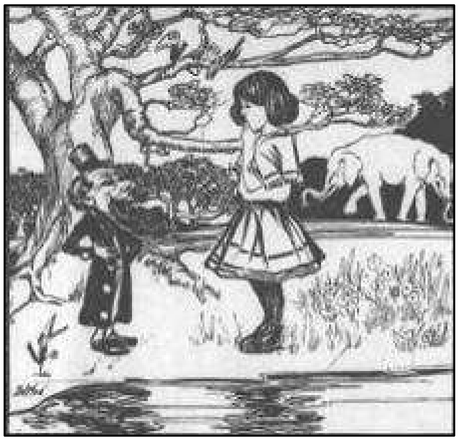
Down in what's now forgotten as being underground, Alice finds the sea,

> *At this moment her foot slipped, and splash! she was up to her chin in salt water. Her first idea was that she had fallen into the sea: then she remembered that she was under ground, and she soon made out that it was the pool of tears she had wept when she was nine feet high.*



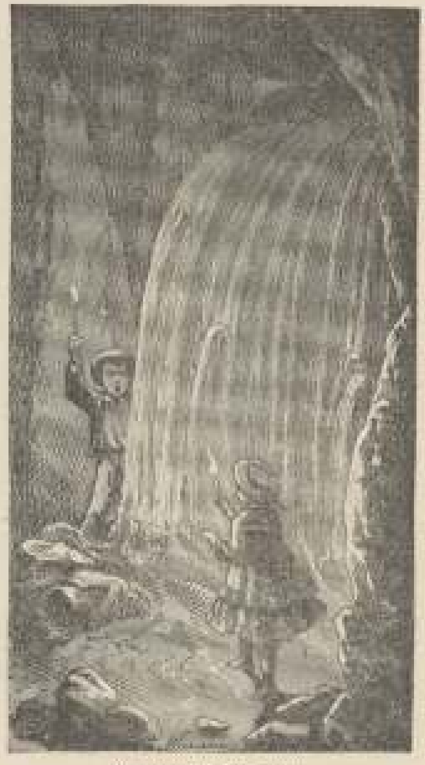
"Goldilocks' Adventure in Fairyland Under Old Mount Tamalpais" by David H. Walker, San Francisco Call, September 16, 1906, lifts unabashedly from Alice, except in this case, the heroine gets to sail on the underground river.

> *Enter the door that bears the words. "This Way to Fairyland," as you climb up Mount Tamalpais, and you shall come on a flight of marble steps that leads down, down, down ever so far going round and round, and then you will come to see an underground river and a boat. If you get into the boat it will sail wherever the fairies wish it to go, only it is sure to stop at some places or other in Fairyland, the land that is under Tamalpais Mountain.*



Mark Twain (Samuel Langhorne Clemens, 1835-1910)

UNITED STATES POSTAGE
SAMUEL L. CLEMENS
10 CENTS



WONDERS OF THE CAVE.

Mark Twain
Cave
$15.95

Twain, on the other hand, wasn't bound by classical precedent. His underground river pointed to literary frontiers.

With the publication of The Adventures of Tom Sawyer (1876), McDougal's Cave became a celebrated tourist attraction and it has been so ever since, by lantern until 1939, electrically lit since. Tom and Becky's underground adventure has probably been responsible for more candles and string taken into the dark than can be counted.

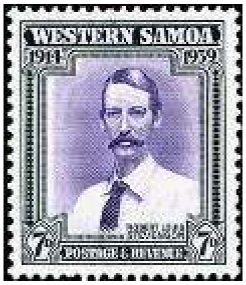
When Tom and Becky encounter an underground stream, note Twain's care to describe the river's role in cave formation.

> *Presently they came to a place where a little stream of water, trickling over a ledge and carrying a limestone sediment with it, had, in the slow-dragging ages, formed a laced and ruffled Niagara in gleaming and imperishable stone... This shortly brought them to a bewitching spring, whose basin was incrusted with a frostwork of glittering crystals; it was in the midst of a cavern whose walls were supported by many fantastic pillars which had been formed by the joining of great stalactites and stalagmites together, the result of the ceaseless water-drip of centuries... Tom found a subterranean lake, shortly, which stretched its dim length away until its shape was lost in the shadows. He wanted to explore its borders, but concluded that it would be best to sit down and rest awhile, first. Now, for the first time, the deep stillness of the place laid a clammy hand upon the spirits of the children.*

It's no wonder Tom and Becky got lost; the cave contains nearly 3,500 meters of passages within its 6-hectare mapping.

Tom went on to other explorations, but it was Tom's companion, Huckleberry Finn (1884) who pushed American literature into the arena of social criticism.

What is less well known is the story of the cave itself. Discovered in 1820, the 3-kilometer maze of crisscrossed passages became notorious in 1849 when its owner, a physician interested in cadavers, put a wooden door on the cave and locked it. When it became known that the cave held a copper and glass flask containing the body of the doctor's 14-year-old daughter, the local citizens intervened.



Robert Lewis Stevenson (1850-1894)

We'd have liked to include Stevenson in our catalog, but his adventures were under the sun. It wasn't for lack of familiarity with Charon, however.

Suffering from a severe illness in California in 1880, he drew freely on Charon and the Styx in his correspondence. As noted to his friend, James Walter Ferrier,

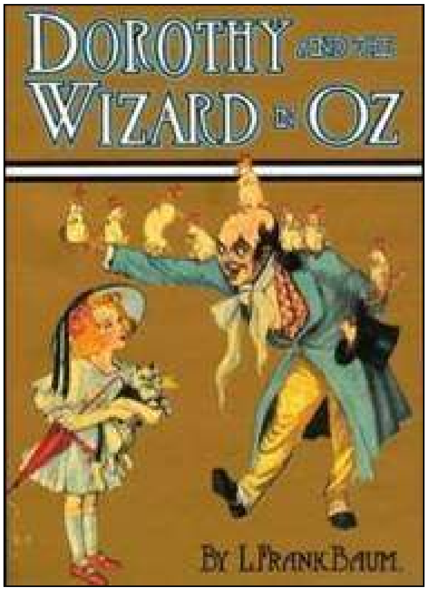
> *I am fresh from giving Charon a quid instead of an obulus; but he, having accepted the payment, scorned me, and I had to make the best of my way backward through the mallow-wood, with nothing to show for this displacement but the fatigue of the journey.*

In another letter,

> *I keep returning, and now hand over fist, from the realms of Hades. I saw that gentleman between the eyes, and fear him less after each visit. Only Charon, and his rough boatmanship, I somewhat fear.*

L. Frank Baum (1856-1919)

The WIZARD
OF Oz
USA
25



Baum is fondly remembered for The Wonderful Wizard of Oz (1900), but not stopping with the Yellow Brick Road, he followed with three more volumes. Dorothy and the Wizard in Oz (1908) was the last. Yes, this one's "in" not "of." Most of the action is outside of Oz, actually, but Baum liked close titles.

Dorothy is sent to visit her uncle who ranches in California. There, Dorothy and friends are riding a buggy when an earthquake swallows them.

> *Yes; there was land below them; and not so very far away, either. But they were floating very, very slowly -- so slowly that it could no longer be called a fall -- -and the children had ample time to take heart and look about them.*
>
> *They saw a landscape with mountains and plains, lakes and rivers, very like those upon the earth's surface; but all the scene was splendidly colored by the variegated lights from the six suns.*

It's not all folly, however. Dorothy encounters her old friend, the Wizard, and they fight invisible bears.

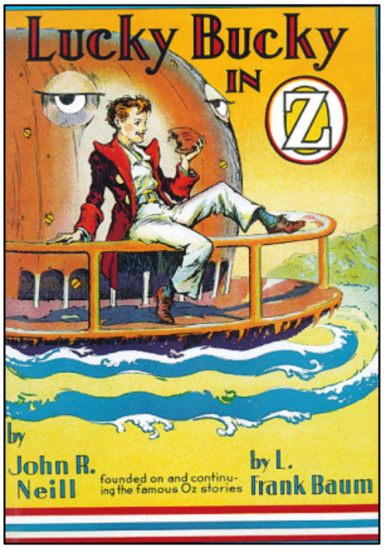
> *"Run for the river!" shouted the Wizard, and Jim quickly freed himself from his unseen tormenters by a few vicious kicks and then obeyed. As soon as he trotted out upon the surface of the river he found himself safe from pursuit, and Zeb was already running across the water toward Dorothy.*
>
> *"I think we'd better stick to the river, after this," said Dorothy. "If our unknown friend hadn't warned us, and told us what to do, we would all be dead by this time."*
>
> *"That is true," agreed the Wizard, "and as the river seems to be flowing in the direction of the Pyramid Mountain it will be the easiest way for us to travel."*

So what do we make of this?

> That Dorothy should be remembered not only for travel by tornado and balloon, but also by underground river.
>
> That Baum should have stopped with his first Oz volume, as by the fourth, the novelty's spent.

And if the spell was wearing thin by the fourth, what must be the quality of the 36th?

Lucky Bucky in Oz (1942) was by John R. Neill, but the series is still credited to Baum. Caught in a tugboat explosion in New York Harbor not far from the Statue of Liberty, young Lucky Bucky is pitched high into the stratosphere, eventually landing safely on a volcanic island next to Oz. Rescued by Davy Jones, a wooden whale, the new friends travel together to the Emerald City. But along the way, the two are swept down the underground river and into the kingdom of the gnomes.


Lucky Bucky IN OZ
by John R. Neill
founded on and continuing the famous Oz stories
by L. Frank Baum

And of course Jim Henson's Muppets would want to find the Emerald City. The Muppets' Wizard of Oz (2005).discussion from The Muppet Central Forum speaks to the nature of the underground river,

> *Okay! Onward to the water and to find our way to the Emerald City Palace!*
>
> *The Muppets began walking down the cave toward the running water and soon they found an underground river. There was little space beside it to walk, but what appeared to be a little boat carved from a tree floated near them and was tied to a rock. The river was deep enough that you couldn't really see the bottom, and it was still and quiet, but the water was flowing in one direction, so the Muppets hopped into the boat and began riding the underground river wherever it would take them.*
>
> *This is nice! I like this. It's like the ride at the fair where you ride the boat through the little tunnel...except there, there's monsters and stuff and you don't think anything will happen in this river do you?*
>
> *Do you?*
>
> *Naaahhh. It's too still of water for something to be going on.*

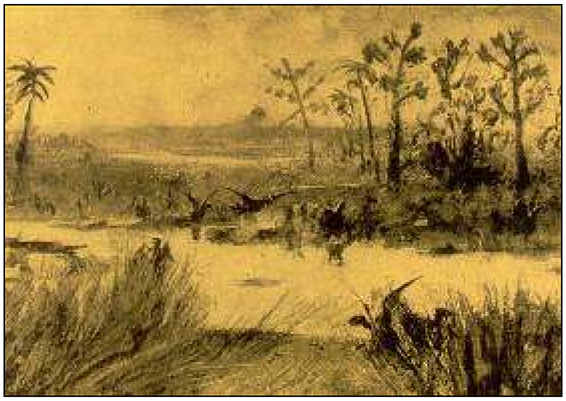
Lessons:

Keep that river moving.

Don't keep licensing a beloved classic. Reputation is worth more than royalties.

Arthur Conan Doyle (1859-1930)

1ST
Sir Arthur Conan Doyle 1859-1930
Writer and creator of Sherlock Holmes



Arthur Conan Doyle practiced medicine in Hampshire. But once his A Study in Scarlet (1887) introduced Sherlock Holmes and his sidekick Dr. Watson to the reading public, its creator had no time to practice medicine.

Doyle wrote much more than mysteries. The Lost World (1912) was his effort at a popular "boy's book," a tale chronicling the adventures of explorers who discover dinosaurs and ape-men in the jungles of South America. At one point, the explorers evaluate a lake with no visible outlet.

> *"It is more than likely that the lake may be an old crater," said Summerlee. "The whole formation is, of course, highly volcanic. But, however that may be, I should expect to find the surface of the plateau slope inwards with a considerable sheet of water in the center, which may drain off, by some subterranean channel, into the marshes of the Jaracaca Swamp."*
>
> *"Or evaporation might preserve an equilibrium," remarked Challenger, and the two learned men wandered off into one of their usual scientific arguments, which were as comprehensible as Chinese to the layman.*

In the manner of his popular mysteries, Doyle added a professorial character to elucidate the reader. Elementary, my dear Watson. Outflow equals inflow less evaporation less underground discharge to Jarracaca Springs.

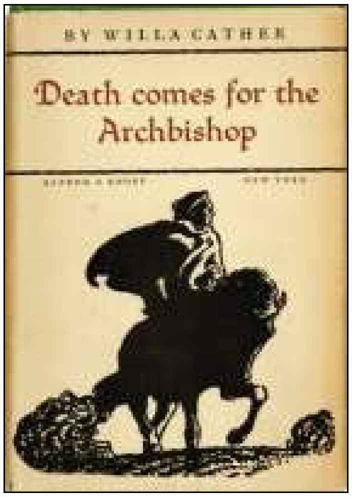
Doyle's wife, chronically ill, died in 1907. His son perished in the Great War and Dole's last years turned increasingly toward spiritual quest, and in particular, desire to communicate with the deceased. Doyle's Tales of Terror and Mystery (1922) included the short story "The Terror of Blue John Gap." This work was, as its title suggests, not written to celebrate science.

> *The farm consists of grazing land lying at the bottom of an irregular valley. On each side are the fantastic limestone hills, formed of rock so soft that you can break it away with your hands. All this country is hollow. Could you strike it with some gigantic hammer it would boom like a drum, or possibly cave in altogether and expose some huge subterranean sea. A great sea there must surely be, for on all sides the streams run into the mountain itself, never to reappear.*
>
> *My view is -- and it was formed, as is shown by my diary, before my personal adventure--that in this part of England there is a vast subterranean lake or sea, which is fed by the great number of streams which pass down through the limestone. Where there is a large collection of water there must also be some evaporation, mists or rain, and a possibility of vegetation. This in turn suggests that there may be animal life, arising, as the vegetable life would also do, from those seeds and types which had been introduced at an early period of the world's history, when communication with the outer air was more easy.*

As Doyle embraced spiritualism, the behavior of his great underground sea became less elementary.

Willa Cather (1873-1947)

US 8c
AMERICAN NOVELIST
WILLA CATHER



We'll have more to say about the literary device in Chapter 29, but here's a metaphor from Cather's O Pioneers, Winter Memories, II (1913).

> *Her personal life, her own realization of herself, was almost a subconscious existence; like an underground river that came to the surface only here and there, at intervals months apart, and then sank again to flow on under her own fields. Nevertheless, the underground stream was there.*

From "Coming, Aphrodite!" in Youth and the Bright Medusa (1920),

> *The Captive took out the bar that was beneath a stone in the floor of the passage, and put in its stead a rush-reed, and the youth stepped upon it and fell through into a cavern that was the bed of an underground river, and whatever was thrown into it was not seen again.*

And here is arguably the best penned passage pertaining to an underground river in the whole of literature. It's worth reading twice.

> *Father Latour lay with his ear to this crack for a long while, despite the cold that arose from it. He told himself he was listening to one of the oldest voices of the earth. What he heard was the sound of a great underground river, flowing through a resounding cavern. The water was far, far below, perhaps as deep as the foot of the mountain, a flood moving in utter blackness under ribs of antediluvian rock. It was not a rushing noise, hut the sound of a great flood moving with majesty* and power. -- Death Comes for the Archbishop (1927)

The archbishop-to-be listens to the earth giving birth.

Jack London (1876-1916)

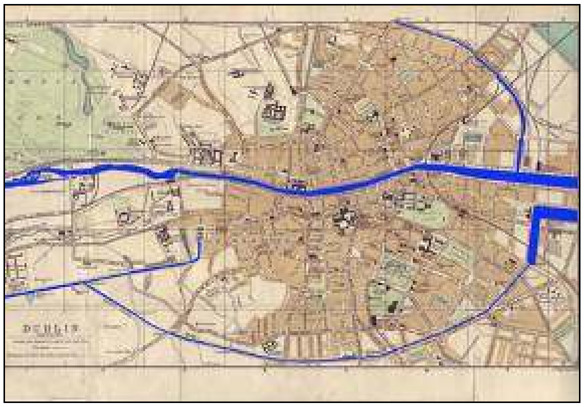
From A Son of the Sun (1912),

> *Several times filling and emptying his lungs in diver fashion, Grief turned over and went down through the water. Salt it was to his lips, and warm to his flesh; but at last, deep down, it perceptibly chilled and tasted brackish. Then, suddenly, his body entered the cold, subterranean stream. He removed the small stopper from the calabash, and, as the sweet water gurgled into it, he saw the phosphorescent glimmer of a big fish, like a sea ghost, drift sluggishly by.*

USA
25
Jack London

James Joyce (1882-1941)

ULYSSES BY JAMES JOYCE
ULYSSES
65c
ÉIRE



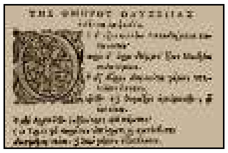
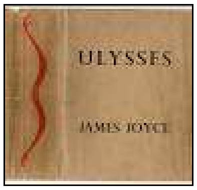
Ulysses Rivers, Dublin

We attach Joyce because we cannot ignore a penultimate work that draws so explicitly upon four of the five classical underground rivers. Joyce saw the Odyssey as literature's most well-rounded human portrait. That much said, Joyce's literary style is beyond most of us.

A few riverine quotations,

> *I moved among them on the frozen Liffey, that I, a changeling, among the spluttering resin fires. I spoke to no-one; none to me.*
>
> *From its sluice in Wood quay wall under Tom Devan's office Poddle River hung out in fealty a tongue of liquid sewage.*
>
> *A covey of gulls, storm petrels, rises hungrily from Liffey slime with Banbury cakes in their beaks.*

Here's how Joyce's' Ulysses stacks up against the Odyssey.

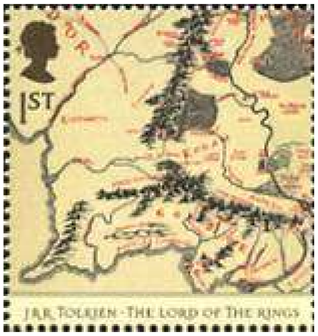
	 Odyssey (c. 855 BC)	 Ulysses (1922)
Author	Homer	James Joyce
Protagonist	Odysseus	Leopold Bloom
Setting	Mythical Mediterranean, Mythical times	Dublin, 1904
Opening	*Tell me, O muse, of that ingenious hero who travelled far and wide after he had sacked the famous town of Troy.*	*Stately, plump buck Mulligan came from the stairhead, bearing a bowl of lather on which a mirror and a razor lay crossed.*
Characters	Lotus Eaters Cyclops Sirens	Pharmacist Citizen in pub Barmaids
Rivers	Acheron Cocytus Styx Lethe Pyriphlegethon	Grand Canal Royal Canal Dodder Liffey

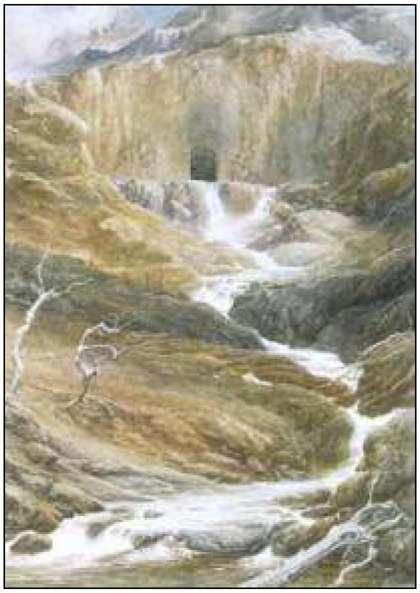
D.H. Lawrence (1885-1930)

From Women in Love (1920),

> *Strange, and desolate above all things, like disembarking from the Styx into the desolated underworld, was this landing at night. There was the raw, half-lighted, covered-in vastness of the dark place, boarded and hollow underfoot, with only desolation everywhere.*

J.R.R. Tolkien (1892-1973)





Tolkien, a professor of philology (the use of language in literature) at Oxford, is best remembered not for his expertise in ancient tongues of Northern Europe, but for his fantasy Middle Earth imagined in meticulous linguistic, geographic and historical detail. It took Tolkien four-volumes to tell the story.

The Hobbit (1937). The Hobbit Bilbo Baggins joins a company of dwarves and the Wizard Gandalf in a quest to reclaim an old dwarfish kingdom from the dragon Smaug.

The Fellowship of the Ring (1954), Part 1 of The Lord of the Rings. Bilbo's cousin and heir Frodo Baggins sets out on a quest to rid Middle Earth of the One Ring, joined by the Fellowship of the Ring.

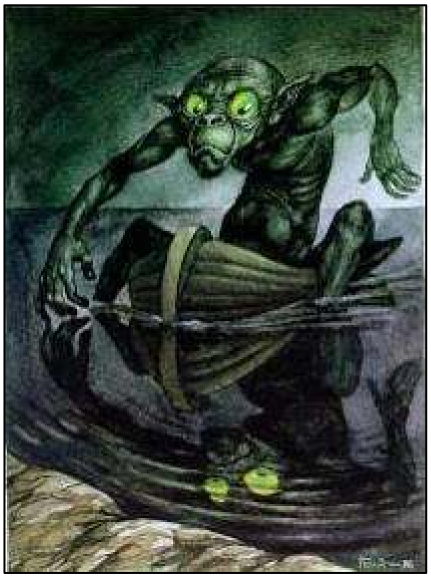
The Two Towers (1954), Part 2 of The Lord of the Rings. The Fellowship is split apart while Frodo and his servant Sam continue their quest. Aragorn, Gimli and Legolas fight to rescue the hobbits Pippin and Merry from the Orcs and to save the Kingdom.

The Return of the King (1955), Part 3 of The Lord of the Rings. Frodo and Sam reach Mordor, while Aragorn arrives in Gondor and reclaims his heritage.

Good battles Evil and, at last, triumphs.

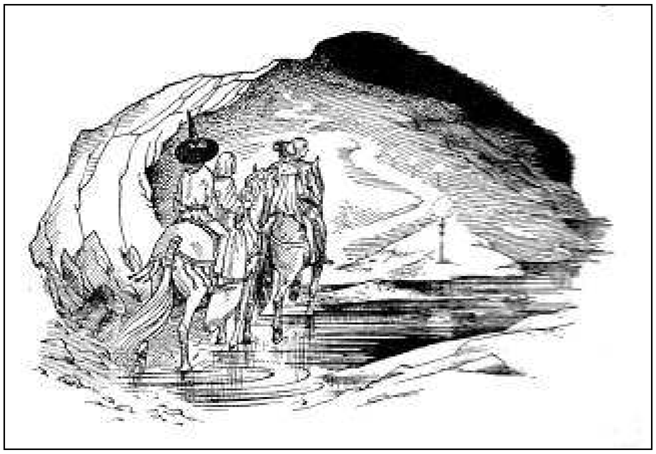
As a setting, Tolkien's geographic creation wasn't underground at all. To Tolkien, "Middle Earth" was an historical term derived from Old English "middangeard," the physical world in which humans live, as opposed to the unseen Heaven and Hell. Tolkien's Middle Earth is our earth ages ago when hobbits quietly dwelt before humans were aware of them.

Tolkien's setting does contain underground rivers, however. The saga features gloomy caverns and ultimately, Mengroth, the underground palace. Gollum, as drawn to the right by Nicholas Bayrachny, lives in a cave near a subterranean river. The river in Silmarillion dips underground and flows out of a cliff miles away. The source of the River Running is under the Lonely Mountain, the waters pouring out of an opening in the rock wall just inside the Front Gate.



C.S. Lewis (1898-1963)

97
ASLAN
CS LEWIS'S NARNIA



River Shribble, marking the boundary
between Narnia and the lands of the giants

The Silver Chair (1953). Narnia is in peril and only Eustace and Jill can help. Along with gloomy Marsh-wiggle Puddleglum, they are sent by the mighty lion Aslan to find Prince Rilian, heir to the throne. Their quest leads them deep into the dark underground.

> *In this way they came to the edge of the chasm. It was about a thousand feet long and perhaps two hundred wide. They dismounted from their horses and came to the edge, and looked down into it. A strong heat smote up into their faces, mixed with a smell which was quite unlike any they had ever smelled. It was rich, sharp, exciting, and made you sneeze. The depth of the chasm was so bright that at first it dazzled their eyes and they could see nothing. When they got used to it they thought they could make out a river of fire, and, on the banks of that river, what seemed to be fields and groves of an unbearable, hot brilliance-though they were dim compared with the river.*

Of another underground river, less Pyriphlegethon,

> *Low tide was running up the valley like a mill-race, and if it had come to swimming, the horses could hardly have won over. But it was still only a foot or two deep, and though it swished terribly round the horses' legs, they reached the far side in safety.*

When in a parallel to Plato's cave, Lewis' Lady of the Green Kirtle tries to convince the children that there is no world outside, Puddleglum notes, "And there's one thing about this underground work, we shan't get any rain."

John Cheever (1912-1982)

In Cheever's "The Swimmer" (1978), a familiar landscape is seen anew.

> *This was at the edge of the Westerhazys' pool. The pool, fed by an artesian well with a high iron content, was a pale shade of green. It was a fine day. In the west there was a massive stand of cumulus cloud so like a city seen from a distance -- from the bow of an approaching ship -- that it might have had a name. Lisbon. Hackensack. The sun was hot. Neddy Merrill sat by the green water, one hand in it, one around a glass of gin.*
>
> *He had been swimming and now he was breathing deeply, stertorously as if he could gulp into his lungs the components of that moment, the heat of the sun, the intenseness of his pleasure. It all seemed to flow into his chest. His own house stood in Bullet Park, eight miles to the south, where his four beautiful daughters would have had their lunch and might be playing tennis. Then it occurred to him that by taking a dogleg to the southwest he could reach his home by water. He seemed to see, with a cartographer's eye, that string of swimming pools, that quasi-subterranean stream that curved across the county. He had made a discovery, a contribution to modern geography; he would name the stream Lucinda after his wife.*

William Kittredge (b. 1932)

In "The Underground River" (1984), such a river is where one disposes of a body,

> *Lately, since Lonnie'd left, he had been imagining the water sound even when he wasn't hearing it. All his life had gone to bed with that murmur, awakened with it, slept beneath it lain sleepless listening to Lonnie's tubercular breath and the summer water.*
>
> *A half mile below his house the river vanished underground. Cleve had dreamed of the river, and because of that dream, because Lonnie's death and the dream were all connected with the sound of water falling, he wanted to send Lonnie down through the boulders to the place where the water was sucked into the earth. The water fell between boulders in a long black lava rockslide to resurface at the bottom of the ridge, over a mile away, and the sound of the falling was hollow, as if the water dropped a great distance onto a plate of steel.*

"Mysterious Pools," Quincy Daily Herald; June 20, 1894, mentions an ominous rumor along this very line.

> *North of Gainesville is a pretty any mysterious spot called the "Devil's Millhopper." A large stream of water comes down a hill with considerable force and disappears in a pool that has no visible outlet. Near Brooksville is another stream very similar to Devil's Millhopper. A stream of water pours into it and disappears in a whirlpool in the center. Throw a log in it and it will circle the pool many times, gradually drawing near to the center. Suddenly the log disappears.*
>
> *Some gruesome stories are connected to the Brooksville pool. It is said that the place is haunted, for the reason that many a man, and woman, too, has mysteriously disappeared in it, never to be heard of afterward. In the pioneer days of that part of the country, so the stories go, there was a secret society which washed all its dirty linen in that pool. In other words, if a man or woman gave offense to any member of the society, he or she was gagged, bound and in the darkness of night thrown into the pool.*

The table summarizes the variety of the subterranean hydrologic features envisioned by some of our authors.

Author	Works	Entrance	Springs	Rivers	Seas	Flesch-Kincaid Grade Level
John Milton	Paradise Lost (1658)	Satan's Trickery	Yes	Yes	Yes	N.A. because of poetic style
Edgar Allan Poe	MS. Found in a Bottle (1833) A Descent into the Maelstrom (1841) The Narrative of Arthur Gordon Pym (1850)	Antarctic whirlpool Arctic whirlpool. Antarctic whirlpool			Yes.	11.5
James Carroll	Alice in Wonderland (1865)	Rabbit hole			Yes	6.3
Mark Twain	The Adventures of Tom Sawyer (1876)	Cave		Yes		5.7
L. Frank Baum	Dorothy and the Wizard in Oz (1908)	Swallowed by earthquake		Yes		4.2
Arthur Conan Doyle	The Lost World (1912)	South American jungle		Yes		8.0
J.R.R. Tolkien	Lord of the Rings (1954-1955)	Fantasy	Yes	Yes	Yes	4.1
C.S. Lewis	The Silver Chair (1953)	Willpower		Yes	Yes	4.2
James Joyce	Ulysses (1922)					4.1
Willa Cather	Death Comes for the Archbishop (1927)	Cave sacred to the Indians		Yes		6.8

The Flesch-Kincaid Grade Level score rates text on a U.S. grade-school level, based on sentence length and syllables/word, but not on vocabulary. An 8.0 means that an eighth grader can understand the document. When it comes to underground rivers in English fiction, only Poe requires the proficiency of high school graduate. Joyce's 4.1 seems inexplicable until we realize that his short words are sufficient to tax our comprehension.

Acclaimed as these authors may be, however, none demonstrates much hydrologic imagination. Chapters 19-25 consider writers of perhaps less literary pedigree, but more creativity regarding waters below.

CHAPTER 17

UNDERGROUND RIVERS IN CONTINENTAL FICTION

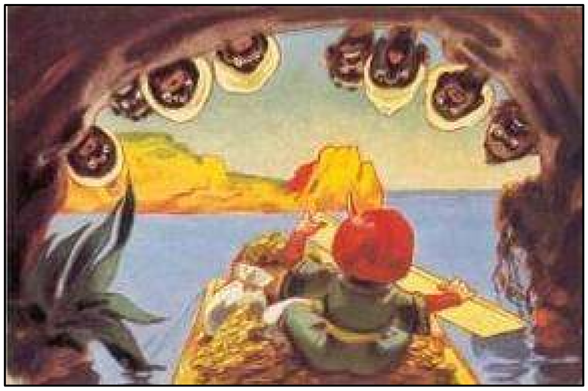
The previous chapter dealt with contributions to English literature; this chapter deals with writings in other languages.

We'll begin with a collection of Persian tales from times long past -- the legend of Sinbad the Sailor, popularized as part of Richard Burton's (not the actor of the same name) 1885 translation of 1,001 Arabian Nights, the number 1,001 being Burton's embellishment.

According to Christa A. Tuczay, "Motifs in the Arabian Nights and in Ancient and Medieval European Literature, a Comparison," Folklore, December 2005, seven motifs from 1,001 Arabian Nights made their way into the fabric of Western sensibilities.

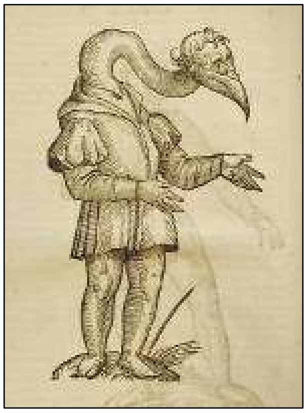
The Magnetic Mountain
The Congealed Sea
The Flying Griffins
The Automaton and the Genie in the Bottle
The Walled City and the World's Vanities
The Living Island
The Subterranean River, our precise interest.

In Sinbad's sixth voyage he is shipwrecked once again -- our adventurer has a propensity for such misfortune, it seems -- and from his raft he discovers a subterranean waterway emerging from a rocky archway beneath the cliffs of a mysterious island.



Sinbad falls asleep as he drifts into the channel -- it is not clear why he floats upstream, but this is Sinbad -- to awaken in the Kingdom of Serendib (modern-day Sri Lanka) where "diamonds are in its rivers and pearls are in its valleys."

The illustration of Sinbad emerging is from a German publication of the 1930s. We can blame the Nazis for the racial stereotypes, but we'd have given it little thought back then.



In the medieval German saga Herzog Ernst (c. 1180), the protagonist travels through the Orient in search of the Holy Grave, encountering such wonders as creatures with human bodies and crane's heads and as a nod to Odysseus, a Cyclops. After escaping from a magnetic mountain, Ernst follows a river too broad and swift to cross which carries him into another mountain. From the channel wall, our hero breaks off the "orphan" jewel destined to adorn the German imperial crown.

In the 13th-century French epic Chanson de Esclarmonde, an angel advises the hero, Huon, to follow the subterranean river lined with precious stones into the mountain Tenebree.

In the Old English Boke of Duke Huon of Burdeux, a retelling of the French, the duke's jeweled boat is hurled down a dark passage having great bars of red-hot iron hissing in the water. It's an 11-day underground sail until Huon emerges in the Persian Sea.

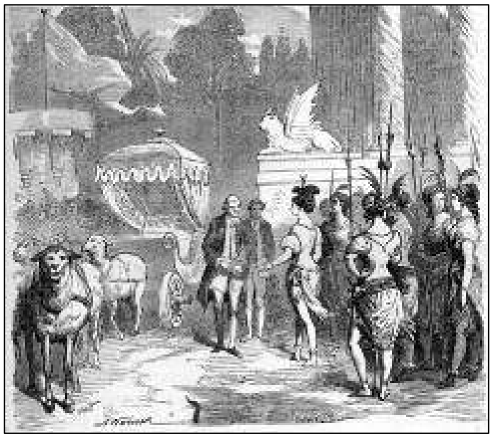
In German, French and English, it's the same bejeweled sojourn on a subterranean river.

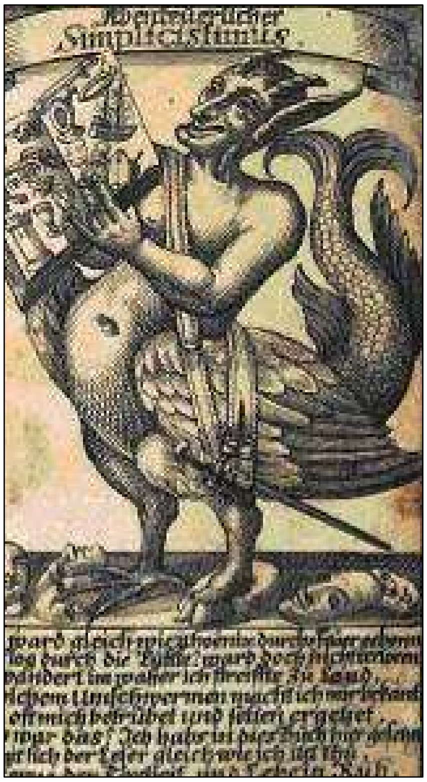
HISTOIRE
DE HUON
DE BORDEAUX.
PAIR DE FRANCE, DUC DE GUIENNE,

Voltaire's Candide (1758) contains parallels to the story of Sinbad, notably where Candide and his valet Cacambo visit the utopian South American city of Eldorado, surrounded by unscalable mountains and reachable only by a 24-hour underground boat ride. Whereas the Arabian Nights focuses on the narrative themes of providence and destiny, Voltaire substitutes the interference of divine power with human intervention.

Cacambo speaks,

> *"We can go no farther, we have walked far enough; I can see an empty canoe in the bank, let us fill it with cocoanuts, get into the little boat and drift with the current; a river always leads to some inhabited place. If we do not find anything pleasant, we shall at least find something new."*
>
> *The river continually became wider; finally it disappeared under an arch of frightful rocks which towered up to the very sky. The two travelers were bold enough to trust themselves to the current under this arch. The stream, narrowed between walls, carried them with horrible rapidity and noise. After twenty-four hours they saw daylight again; but their canoe was wrecked on reefs; they had to crawl from rock to rock for a whole league, and at last they discovered an immense horizon, bordered by inaccessible mountains. The country was cultivated for pleasure as well as for necessity; everywhere the useful was agreeable.*





Johann Jakob Christoffel von Grimmelshausen published Der Abenteuerliche Simplicissimus (1669, The Adventurous Simplicissimus), chronicling portions of the Thirty Years War, but not constrained to bellicose history. Grimmelshausen's protagonist, the speculative Simplicissimus, visits Lake Mummelsee, the portal to an underworld not unlike that of Greek mythology.

> *I did inspect the lake, and found lying in it certain hewn timbers of the Würtemberg raft; and I by geometry took or estimated the length and breadth of the water (for 'twas far too wearisome to go round the lake and measure it by paces or feet), and entered the dimensions, by means of the scale reduction, in my tablets.*
>
> *I walked along the lake to the left, where the water, which elsewhere is as clear as a crystal, doth begin, by reason of the monstrous depth, to show as black as coal, and therefore is so dreadful of appearance that the mere look of it doth terrify. And there I began to cast in stones as great as I could carry.*
>
> [I] *turned not mine eyes away from the depths of the lake, expecting to see certain bladders or bubbles rising up from the bottom, as is wont to happen when stones are thrown into deep water whether still or running*
>
> *Yet saw I naught of the kind, but was ware of certain creatures floating far down in the depths which in form reminded me of frogs, and flitted about like sparks from a mounting rocket which in the air doth work its full effect, and as they came nearer and nearer to me they seemed to grow larger and more like to human form, at which at first great wonder took hold of me, a great fear and trembling. "Ah," said I then to myself in my terror and wonder, and yet so loud that my dad, that stood beyond the lake, could her me, though the noise of the thunder was dreadful, "how great are the wondrous works of the Creator! yea, even in the womb of the earth and the depths of the waters!"*

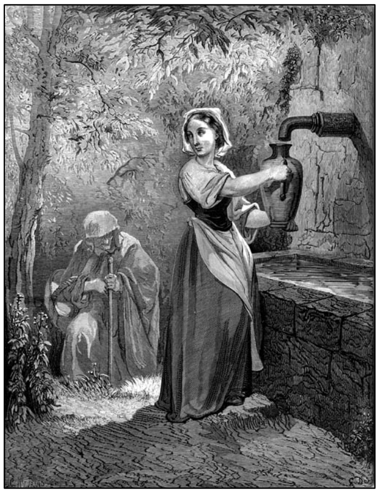
Simplicissimus is spokesperson of the Natural Philosophy of his times (Chapter 13, Hydrotheology/Theohydrology). The flittering water spirits then guide him to the center of the earth where the traveler unfortunately (for us, at least) ceases to maintain his hydrological journal.

Charles Perrault (one of the talented brothers we met in Chapter 12, Superterranean Metrics) did not invent the moralistic plots of his stories, but gave literary legitimacy to what were already folk tales. Modern readers know his Histoires ou Contes du Temps Passé (1697, Tales and Stories of the Past with Morals) by its subtitle Les Contes de ma Mère l'Oie, Tales of Mother Goose.

Within Mother Goose were Blue Beard, Sleeping Beauty, Little Red Riding Hood, Puss in Boots and Cinderella. (We'll get to Walt Disney, who capitalized greatly on such lore, but not until Chapter 24, Underground Rivers in the Comics.)

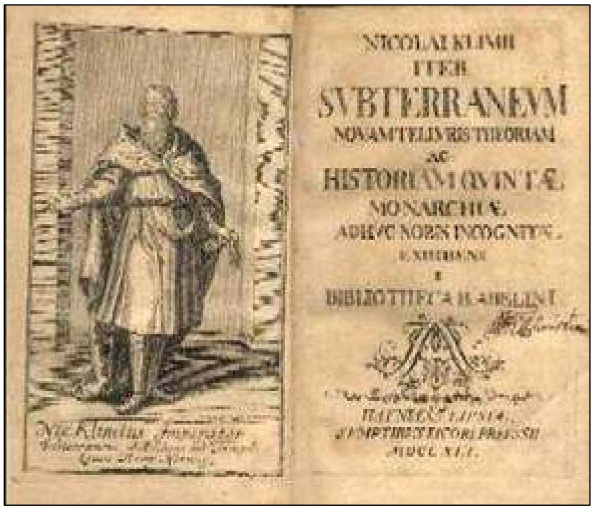
Perrault's "The Fairies" is set at a spring, the story of a younger sister, gentle and sweet, and her older sister, disagreeable and arrogant. Of the younger,

> *One of the poor child's many duties was to go twice a day and draw water from a spring a good half mile away, bringing it back in a large pitcher. One day when she was at the spring an old woman came up and begged for a drink.*
>
> *"Why, certainly, good mother," said the beautiful girl. Rinsing the pitcher, she drew some water from the cleanest part of the spring and handed it to her, lifting up the pitcher so that she might drink more easily.*
>
> *Now this old woman was a fairy.*



The remainder is somewhat predictable, as Mother Goose tends to be. Charles did not publish Mother Goose under his own name, but rather under the name of his son Pierre. Thus there were two Pierre Perraults, uncle and nephew, who wrote about water from springs, one for the Académie des Sciences, the other for les enfants.

Norwegian **Ludvig Holberg**'s Nicolai Klimii iter Subterraneum (1741, Nicholas Klim's Subterraneous Journey, written in Latin) was pure and simple science fiction, a description of a utopian society from an outsider's (literally) point of view. Philosophy and theology student Klim falls into a cave and finds himself orbiting a planet revolving around an inner sun. He's attacked by a gryphon, but survives to lands on the planet and explores such topics as the morality, science, sexual equality, religion, and government of this interior world.



NICOLAI KLIMII
ITER
SVBTERRANEVM
NOVAM TELLVRIS THEORIAM
AC
HISTORIAM QVINTÆ
MONARCHIÆ
ADHVC NOBIS INCOGNITÆ
EXHIBENS
E
BIBLIOTHECA B. ABELINI

HAFNIÆ & LIPSIÆ,
SVMPTIBVS IACOBI PREVSSII
MDCCXLI.

But most of interest (to us, at least) is Holberg's hydrology.

> *The country is intersected by greater and lesser canals, on which boats propelled by oars, skim with wonderful celerity. The oars are driven by self-moving machines, so quietly that very little motion is given to the water.*
>
> *The waters are filled with fish, and upon the banks of the rivers are seated splendid country houses.*
>
> *There are numberless silver mines within its borders; the sand of its rivers is colored by gold, and its coasts are paved with pearl oysters of the finest water.*
>
> *At the time of my arrival the water was very high, owing to the nearness of Nazar. This planet has the same effect upon the tides of the firmament, as our moon has upon those of the earth.*

> *Every movable thing on deck floated off, for besides the ever-rolling billows, an immense rain fell in terrific water-spouts, accompanied by thunder and lightning. It seemed as though all the elements had conspired for our destruction.*

Based on Klim's account, water in the underworld seems to satisfy the same needs and present the same challenges as water in the outer world. As Holberg would wish us to believe, we've much to learn from such places.

Victor Hugo's Les Miserables (1862) is an underground river tale, albeit an unpleasant waterway, but it can wait until Chapter 58, The Grand Tour, European Sewers of Distinction.

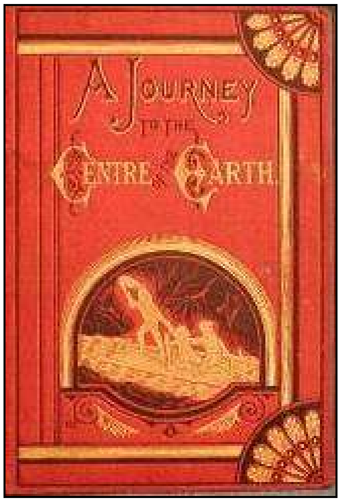
1F25
POSTES
VICTOR HUGO
RF

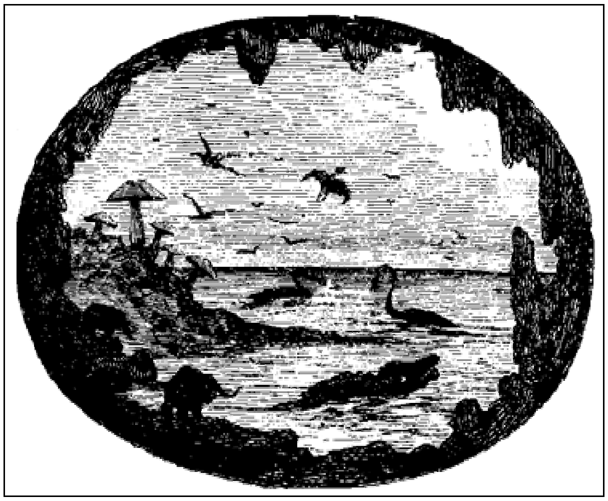
And now we arrive at perhaps the most-celebrated underground adventurist of all, **Jules Verne** (1828-1905).

Edgar Allan Poe was translated into French when Verne was 26 and Verne became a devoted admirer of the American, writing a sequel to Poe's unfinished narrative of Gordon Pym, The Sphinx of the Ice-Fields (1897).

REPUBLIQUE FRANCAISE
30F
JULES VERNE

At the center of Verne's works is the heroic scientist whose startling discoveries caught the enterprising spirit of the 19th century and its uncritical fascination with scientific progress. The popular science context in which Verne wrote Voyage au Centre de la Terre (1864, Journey to the Center of the Earth) included notions of a hollow earth proposed by John Cleves Symmes (Chapter 14). But Verne wasn't satisfied with make-believe, interviewing geographer Charles Sainte-Claire Deville who had explored the volcanoes of Teneriffe and Stromboli, where the Journey adventurers emerge at the end of their expedition.





Verne's rivers are pathways to discovery. An excerpt from Journey,

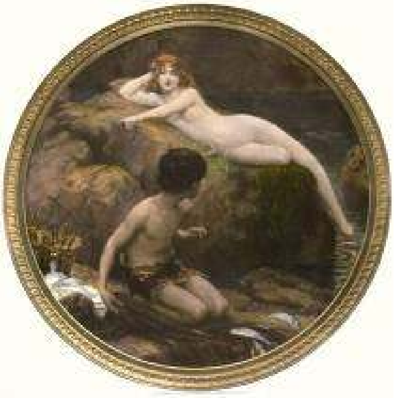
> *Then I began to hear distinctly quite a new sound of something running within the thickness of the granite wall, a kind of dull, dead rumbling, like distant thunder. During the first part of our walk, not meeting with the promised spring, I felt my agony returning; but then my uncle acquainted me with the cause of the strange noise.*

> *"Hans was not mistaken," he said. "What you hear is the rushing of a torrent."*
>
> *"A torrent?" I exclaimed.*
>
> *"There can be no doubt; a subterranean river is flowing around us."*

And not much later, they puncture the steam below.

> *The pick had soon penetrated two feet into the granite partition, and our man had worked for above an hour. I was in an agony of impatience. My uncle wanted to employ stronger measures, and I had some difficulty in dissuading him; still he had just taken a pickaxe in his hand, when a sudden hissing was heard, and a jet of water spurted out with violence against the opposite wall.*
>
> *The gallery dipped down a very little way from the horizontal, scarcely more than two inches in a fathom, and the stream ran gently murmuring at our feet. I compared it to a friendly genius guiding us underground, and caressed with my hand the soft naiad, whose comforting voice accompanied our steps. With my reviving spirits these mythological notions seemed to come unbidden.*

The naiad of mythological notion is the Greek nymph who presides over fresh water fountains, wells, springs, streams, and brooks. Hylas of the Argo was lost when he was taken by naiads fascinated by his beauty. To the right is an engraving after Herbert James Draper's (1864-1920) painting.



Beyond such allusions to classical myth -- the mention of Virgil and his entrance to the underworld and Pluto, god of that realm, being two others -- Verne's science supersedes mythology. The journey to the underworld is a young explorer's initiation into manhood.

> *At first I saw absolutely nothing. My eyes, wholly unused to the effulgence of light, could not bear the sudden brightness; and I was compelled to close them. When I was able to reopen them, I stood still, far more stupefied than astonished. Not all the wildest effects of imagination could have conjured up such a scene! "The sea -- the sea," I cried.*
>
> *"Yes," replied my uncle, in a tone of pardonable pride; "the Central Sea."*

> *We began to walk along the shores of this extraordinary lake. To our left were abrupt rocks, piled one upon the other -- a stupendous titanic pile; down their sides leaped innumerable cascades, which at last, becoming limpid and murmuring streams, were lost in the waters of the lake. Light vapors, which rose here and there, and floated in fleecy clouds from rock to rock, indicated hot springs, which also poured their superfluity into the vast reservoir at our feet.*

Journey to the Center of the Earth, film version (2008)

> *"What," I cried, rising in astonishment, "did you say the tide, Uncle?"*

> *"And pray why not? Are not all bodies influenced by the law of universal attraction? Why should this vast underground sea be exempt from the general law, the rule of the universe? Besides, there is nothing like that which is proved and demonstrated. Despite the great atmospheric pressure down here, you will notice that this inland sea rises and falls with as much regularity as the Atlantic itself."*

They blast a hole in the roof of the inner earth and the sea crashes down upon them, carrying their raft downward "at an angle steeper than that of the swiftest rapids in America." Their speed increases and then "a water-spout, a huge liquid column" strikes them and then they are propelled up to the outer world. As the Professor explains, "The water has reached the bottom of the abyss and is now rising to find its own level, taking us with it."

The Professor's grasp of hydraulics is questionable, but it works in fiction.

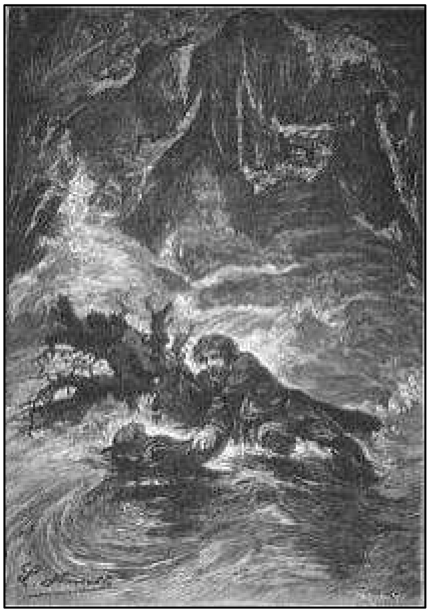
Verne's The Underground City (1911) of course required underground waters.

> *"Mr. Starr," said he, "you see this immense cavern, this subterranean lake, whose waters bathe this strand at our feet? Well, it is to this place I mean to change my dwelling, here I will build a new cottage, and if some brave fellows will follow my example, before a year is over there will be one town more inside old England."*

In terms of a true underground river, however, Verne's epic Mediterranean adventure, Mathias Sandorf (1895) stuck closer to factual (if exaggerated) geology.. "I wish my readers to learn everything they should know about the Mediterranean," Verne wrote, "which is why the action transports them to twenty different places."

Verne may have heard about the foiba (sinkhole) beneath Pisino Castle in the works of Charles Yriarte who described Count Esdorff's search for the end of the connecting underground river. Unfortunately the count's boat never made it out.

> *Then they saw that the rope hung loosely over the abyss. Resting-places, staples, there were none. They were swinging wildly at the end of the rope which cut their hands as it slipped through them. Down they went, with their knees chafing and bleeding, without the power to stop themselves as the bullets whistled past.*
>
> *For a minute, for eighty feet and more, they glided down -- down -- asking themselves if the abyss in which they were engulfed were really bottomless. Already the roar of the raging waters below them could be heard. Then they understood that the lightning-conductor led down into the torrent. What was to be done? To climb back to the base of the donjon they could not; their strength was unequal to the task. And death for death, it was better to chance that which waited for them in the depths below.*
>
> *As soon as Count Sandorf fell into the torrent he found himself swept helplessly into the Buco. In a few moments he passed from the intense light with which the electricity filled the ravine into the profoundest darkness. The roar of the waters had taken the place of the roll of the thunder. For into that impenetrable cavern there entered none of the outside light or sounds.*



There was the complete uncertainty as to the direction which this torrent took, the place it ended, the river or sea into which it flowed. Had even Sandorf known that the river was the Foiba the position could not have been more desperate than if he knew what became of its impetuous waters. Bottles thrown into the entrance of the cavern had never come to sight again in any stream on the Istrian peninsula; perhaps from their having been broken against the rocks in their course, perhaps from having been swept below into some mysterious rift in the earth's crust.

Twenty times were Sandorf and his friend seized in one of these liquid suckers and irresistibly drawn to its centre in the manner of the Maelstrom. Then they would be spun round by the gyratory movement, and then thrown off from the edge like a stone from a sling as the eddy broke.

A violent shock nearly broke his shoulder. Me stretched out his hand instinctively. His fingers closed on a clump of roots which were swimming by.

The roots were those of a tree-trunk being brought down by the torrent. Sandorf fastened on to this raft and dragged himself back to the surface of the Foiba. Then while he grasped the roots with one hand he sought for his companion with the other.

A moment afterwards (Bathory was seized by the arm) and after a violent effort hoisted on to the trunk, where Sandorf took his place beside him. Both were for a time saved from the danger of drowning, but they had bound up their destiny with that of their raft, and given themselves over to the caprices of the rapids of the Buco.

Sandorf had not lost his consciousness for a moment. He made it his first care to make sure that Bathory could not slip from the tree. By excess of precaution he placed himself behind him, so as to hold him in his arms. In this position he kept watch for the end. At the first glimpse of light that penetrated the cavern he would see what the waters were like as they emerged. But there was nothing as yet to show that they were near the end of this wonderful stream. However, the position of the fugitives had improved. The tree was about twelve feet long, and the spreading roots were now and then struck against the projections. If it were not subjected to a very violent shock its stability in spite of the irregularities of the stream seemed to be assured. Its speed could not be less than nine miles an hour, being equal to that of the torrent that bore it.

It was nearly two o'clock in the morning before the speed of the current, and consequently that of the tree, began sensibly to slacken. Evidently the channel was getting wider, and the waters finding a freer passage between the walls were travelling at a more moderate pace. And it was not unreasonable to expect that the end of the subterranean pass was close at hand.

But if the walls were widening, the roof was closing down on them. By raising his hand Count Sandorf could skim the surface of the irregular schists which stretched above his head. Frequently there came a grating noise as the roots of the tree ground against the roof. Then the trunk would stagger as it recoiled from some violent collision and swing off in a new direction. And then it would drift across the stream, and twist and writhe till the fugitives feared they would be wrenched away.

Suddenly through the liquid mass, although his eyes were closed, he felt the impression of a vivid light. A lightning flash, it was, followed by the noise of thunder.

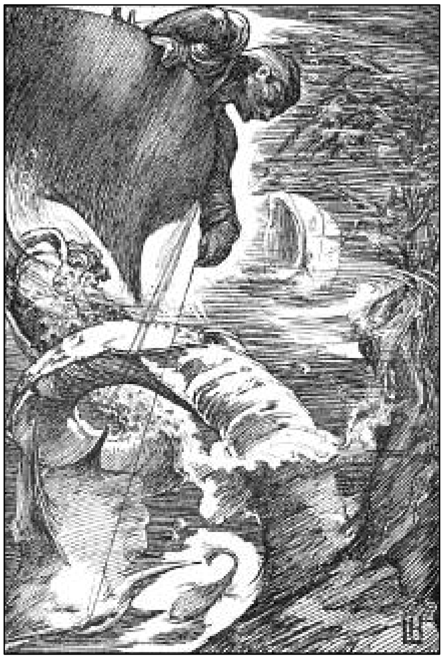
It was the light, at last!

> *The Foiba had emerged from the subterranean channel and was flowing in the open. But whither was it flowing? On what sea-coast was its mouth? That was still the insoluble question -- a question of life or death.*

We earlier noted Symmes' influence on Poe, who in turn influenced Verne, who, if nothing else, inspired others to pen such titles as 1,000 Fathoms Deep, 100 Miles Below the Surface of the Sea, 7,000 Miles Underground and City of the First Men, or 90 Days at the Centre of the Earth.

Admiral Richard Byrd said on the eve of his polar flight, "Jules Verne guides me" and we saw to where in Chapter 14, Hollow Earth Geophysics.

Weird Tales from Northern Seas (1893), a short story by **Jonas Lie** (1833-1908), offers a Norwegian take on the hole-in-the sea tale. As the story's brief and no longer in copyright, we'll quote it in full.



> *It was such an odd trout that Nona hauled in at the end of his fishing-line. Large and fat, red spotted and shiny, it sprawled and squirmed, with its dirty yellow belly above the water, to wriggle off the hook. And when he got it into the boat, and took it off the hook, he saw that it had only two small slits where the eyes should have been.*
>
> *It must be a huldrefish, thought one of the boatmen, for rumor had it that that lake was one of those which had a double bottom.*
>
> *But Nona didn't trouble his head very much about what sort of a fish it was, so long as it was a big one. He was ravenously hungry, and bawled to them to row as rapidly as possible ashore so as to get it cooked.*
>
> *He had been sitting the whole afternoon with empty lines out in the mountain lake there; but as for the trout, it was only an hour ago since it had been steering its way through the water with its rudder of a tail, and allowed itself to be fooled by a hook, and already it lay cooked red there on the dish.*
>
> *But now Nona recollected about the strange eyes, and felt for them, and pricked away at its head with his fork. There was nothing but slits outside, and yet there was a sort of hard eyeball inside. The head was strangely shaped, and looked very peculiar in many respects.*
>
> *He was vexed that he had not examined it more closely before it was cooked; it was not so easy now to make out what it really was. It had tasted first-rate, however, and that was something.*
>
> *But at night there was, as it were, a gleam of bright water before his eyes, and he lay half asleep, thinking of the odd fish he had pulled up.*
>
> *He was in his boat again, he thought, and it seemed to him as if his hands felt the fish wriggling and sprawling for its life, and shooting its snout backwards and forwards to get off the hook.*
>
> *All at once it grew so heavy and strong that it drew the boat after it by the line.*
>
> *It went along at a frightful speed, while the lake gradually diminished, as it were, and dried up.*
>
> *There was an irresistible sucking of the water in the direction the fish went, which was towards a hole at the bottom of the lake like a funnel, and right into this hole went the boat.*

> *It glided for a long time in a sort of twilight along a subterranean river, which dashed and splashed about him. The air that met him was, at first, chilly and cellar-like; gradually, however, it grew milder and milder, and warmer and warmer.*
>
> *The stream now flowed along calmly and quietly, and broadened out continually till it fell into a large lake.*
>
> *Beyond the borders of this lake, but only half visible in the gloom, stretched swamps and morasses, where he heard sounds as of huge beasts wading and trampling. Serpent like they rose and writhed with a crashing and splashing and snorting amidst the tepid mud and mire.*
>
> *By the phosphorescent gleams he saw various fishes close to his boat, but all of them lacked eyes.*
>
> *And he caught glimpses of the outlines of gigantic sea-serpents stretching far away into the darkness. He now understood that it was from down here that they pop up their heads off the coast in the dog days when the sea is warm.*
>
> *The sea serpent, with its flat head and duck's beak, darted after fish, and crept up to the surface of the earth through the slimy ways of mire and marsh.*
>
> *Through the warm and choking gloom there came, from time to time, a cooling chilling blast from the cold curves and winds of the slimy and slippery greenish sea serpent, which bores its way through the earth and eats away the coffins that are rotting in the churchyards.*
>
> *Horrible shapeless monsters, with streaming manes, such as are said to sometimes appear in mountain tarns, writhed and wallowed and seized their prey in the fens and marshes.*
>
> *And he caught glimpses of all sorts of humanlike creatures, such as fishermen and sailors meet and marvel at on the sea, and landsmen see outside the elfin mounds.*
>
> *And, besides, that there was a soft whizzing and an endless hovering and swarming of beings, whose shapes were nevertheless invisible to the eye of man.*
>
> *Then the boat glided into miry pulpy water, where her course tended downwards, and where the earth-vault above darkened as it sank lower and lower.*
>
> *All at once a blinding strip of light shot down from a bright blue slit high, high, above him.*
>
> *A stuffy vapour stood round about him. The water was as yellow and turbid as that which comes out of steam boilers.*
>
> *And he called to mind the peculiar tepid undrinkable water which bubbles up by the side of artesian wells. It was quite hot. Up there they were boring down to a world of warm watercourses and liquid strata beneath the earth's crust.*
>
> *Heat as from an oven rose up from the huge abysses and dizzying clefts, whilst mighty steaming waterfalls roared and shook the ground.*
>
> *All at once he felt as if his body were breaking loose, freeing itself, and rising in the air. He had a feeling of infinite lightness, of a wondrous capability for floating in higher atmospheres and recovering equilibrium.*
>
> *And, before he knew how it was, he found himself up on the earth again.*

Georg Ebers (1837-1898) was a German novelist and Egyptologist whose The Greylock is undated. It, too, is about a fish.

> *"And shall I never see my mother and Wendelin again?" George asked, and the tears poured down over his cheeks like the water over the stalactites.*
>
> *"Oh yes!" the fish replied, "if you are courageous, and do something good and great, then you may return to your home."*

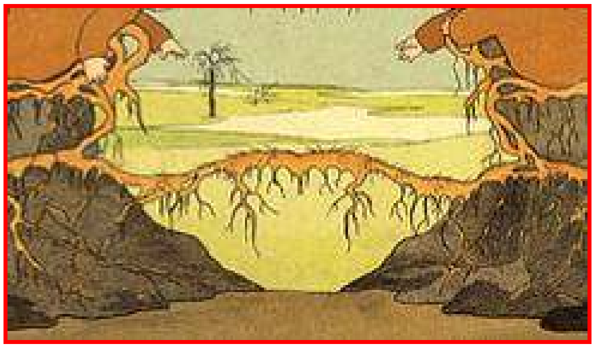
> *"Something good and great," George repeated, "that will be very difficult; and, if I should succeed in doing something that I thought good and great, how could I know whether the fairy considered it so?"*
>
> *"Whenever the greylock grows on your head, you may declare yourself to be the son of a duke and go home," the fish whispered. "Follow me. I will light the way for you. It is lucky that you have run about so much and are so thin, otherwise you might stick fast on the way. Now pay attention. This pool drains itself, through a passage under the mountain, into the lake. I shall swim in front of you until we come to the big basin into which the springs of these mountains empty their waters. After that I must keep to the right, in order to get back into the lake, but you must take the left passage, and let the current carry you along for an hour, when it will join the head of the great Vitale River, and flow out into the open air. Continue with the stream until it turns towards the east, then you must climb over the mountains, and keep ever northwards. Hold your hand under my mouth that I may give you money for your journey."*
>
> *George did as he was bid, and the fish poured forty shining groschen into his hand. Each one of them would pay for a day's nourishment and a night's lodging.*
>
> *The fish then dived under, George plunged after it into the pool, and followed the shimmering light that emanated from his scaly guide. Sometimes the rocky passages, through which he crawled on his stomach in shallow water, became so small that he bumped his head, and had to press his shoulders together in order to pass, and often he thought that he would stick fast among the rocks, like a hatchet in a block of wood. He always managed to free himself, however, and finally reached the big basin, where a crowd of maidens with green hair and scaly tails were sporting, and they invited him to come and play tag with them. But the fish advised him not to stop with the idle hussies, and then parted from him.*
>
> *George was alone once more, and he let himself be borne along on the rushing subterranean stream. At length it poured out into the open air, as the Vitale River, and the boy fell with it over a wall of rock into a large pool surrounded by thick greenery. There was a great splash, the trout were frightened to death, a dog began to bark, and a shepherd, who was sitting on the bank, sprang up, for the colored bundle that had just shot over the falls, now arose from the water and bore the form of a pretty boy of thirteen years.*

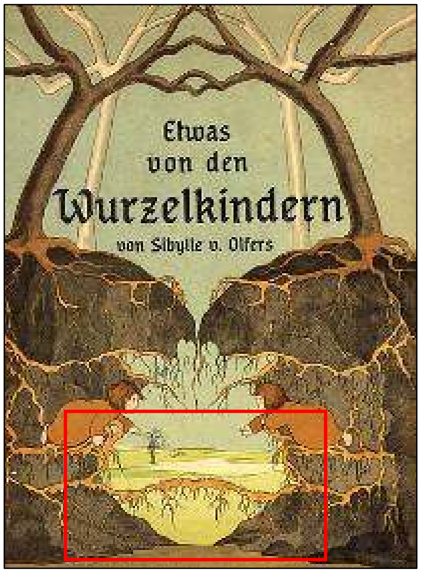
The spectrum of European literature of contains many more examples of such subterranean waters, but our point's made -- underground rivers are a staple setting across Western literature.

CHAPTER 18
PICTURE BOOKS

Our underground river journey now passes through several chapters dealing with juvenile literature. The first such chapter is about illustrated works for young children in which the story is told more through pictures than through words. We'll not, however, include comic books and graphic novels, which while likewise are mostly pictures, are written for those who shouldn't need the drawings.

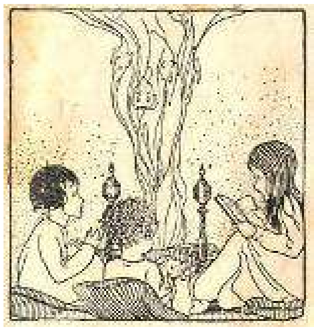
When the Root Children Wake Up (1906) by **Sibylle von Olfers** has been re-issued with various illustrators. The root children who have been sleeping all winter awake to become flower children and experience the new life, the color, and the joys of spring. To the right, a German edition chosen for its underground river depiction.





The Firelight Fairy Book (1919) by **Henry Beston** is a collection of tales, one being "The Queen of Lantern Land."

> *Once upon a time the youngest son of a king became filled with the desire to go abroad and see the world. He got his father's permission to depart, kissed his parents good-bye, mounted his black horse, and galloped away down the high road. Soon the gray towers of the old castle in which he was born hid themselves behind him...*



And soon he was following an underground river.

> *The Prince made his way toward the light, along a narrow beach of white sand lying between the wall of the cavern and the racing waters of the mysterious river, and found that the glow came from a magnificent lantern studded with emeralds, topazes, amethysts, and rubies, which hung by a chain from the roof of the grotto. Directly under this lantern, drawn up on the sand, lay a little boat with a lantern fastened to the bow. The Prince pushed the boat into the river, and got into it, and the swift current seized him and hurried him away.*
>
> *At first the cavern grew higher and wider; then it shrank again, and the boat, borne along with incredible speed, shot down a rocky passageway into the very heart of the earth. The passageway broadened once more, and the boat rode gently through monstrous caves whose roofs were upheld by twisted columns taller than the tallest tree. There were times when all was so still that the Prince could easily have imagined himself back in the solitude of the*

> *mountains; there were times when the foaming and roaring of the underground river grew so deafening that the Prince feared lest he might be approaching the brink of a subterranean cataract...*

And into the underground ocean.

> *Many hours passed. The Prince did not know whether it was night or day. At length, while the boat was gliding through a vast hall, he fell asleep. When he awoke, he found that the boat was floating on the black, glassy surface of an immense underground ocean. All signs of the cavern had disappeared. Far away, over the edge of this ocean, a strange, beautiful glow mounted into the starless sky of the underworld. And while the Prince was gazing at the glow, the boat swung into a new current, and was borne swiftly toward the light. In a short time the light grew so wide and bright that one would have believed that a strange, golden sun had risen. The boat passed between two giant marble pillars supporting enormous crystal globes filled with a golden fire, and the Prince found himself in the harbor of Lantern Land...*

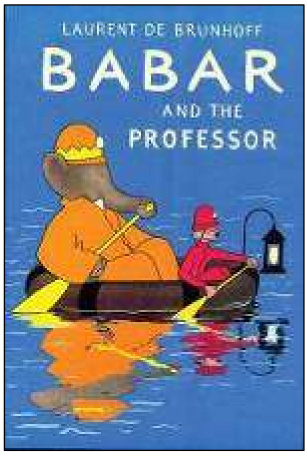
In the harbor, but not out of harms' way.

> *Suddenly the air became filled with a terrible moaning; the sea became troubled; the whirlpool awoke. And the Prince saw the red lights of the Enchanter's ship whirled round and round, faster and faster, till they disappeared forever in the waters of the sunless sea.*

But, of course, all ends well for our little Prince.

> *As for the Prince, he soon found another boat, and taking with him the talisman, his fellow servants, and the black cat and her kittens, he returned to Lantern Land, married the Queen, and lived happily ever after.*

In Babar and the Professor (1957) by **Laurent de Brunhofff**, Professor Grifaton, a butterfly collector, and his children visit King Babar and Queen Celeste. As a result of one of the children falling down a tunnel, a cave is discovered, and in it, among other things, a statue of a giant mammoth and an underground river that leads to the sea.

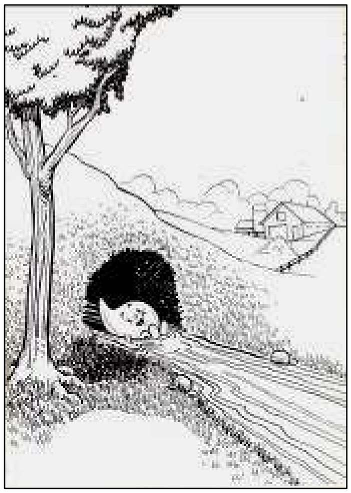


<ins>Splash and Trickle, A Conservation Story, The Adventures of Two Raindrops</ins> (1968) by **Ivan Green** and **Bill Connor** describes the Big Adventure of two raindrops. Splash becomes engulfed in a flood.

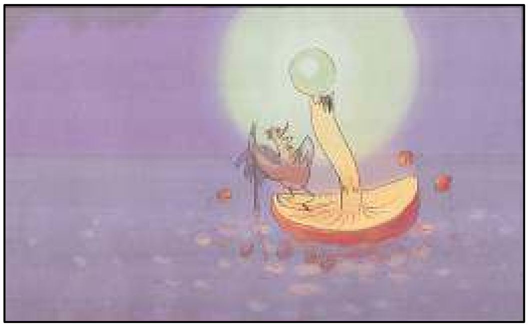
> *Tickle and thousands of other raindrops had joined together for become a little stream, running through the roots and soil underground. He had not traveled far before he found the river.*
>
> *Slowly and quietly they all moved on together, through the cool dark earth. Then after days and weeks of the quiet traveling they saw sunlight again.*

The sequence is explicit: Trickle joins an underground stream
Which joins a river
Which later reaches daylight.

The adventure's fine; the hydrology is not.



The the text-free <ins>Rooster's Revenge</ins> (2011) by **Beatrice Rodriguez** portrays Rooster's sail over the sea into a strange cave with a mysterious glowing ball.



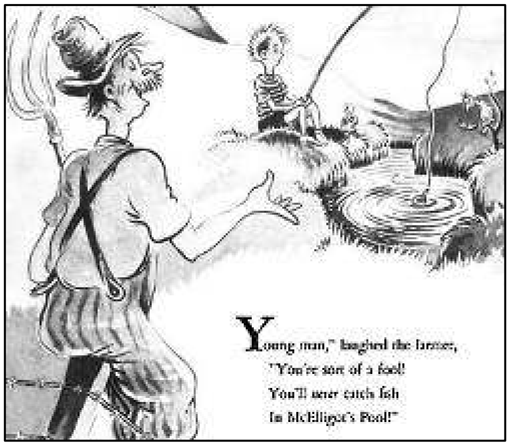
<ins>McElligot's Pool</ins> (1947, long before <ins>The Cat in the Hat</ins>) by **Dr. Seuss** contrasts the sour pessimism of an adult farmer and the unboundedly optimistic dangling boy his fishing line into a small water-filled crack in the earth.

> *You're sort of a fool!*
> *You'll never catch fish in McElligot's Pool!*

The youngster takes that as a challenge to keep doing what they are doing, and this one certainly did.

> *This pool might be bigger than you or I know!*

Perhaps it connects underground all the way to the sea and contains many dog fish, catfish, or "even a fish made of strawberry jelly" not to mention one with a pinwheel-like tail and another with fins like a sail. The book's core is a series of fantastic fish, each more remarkable than the last.


"Young man," laughed the farmer,
"You're sort of a fool!
You'll never catch fish
In McElligot's Pool!"

Having thought about all of these fish, the boy ponders,

> *There might be a pool, like I've read of in books,*
> *Connected to one of those underground brooks.*

An underground river that starts here and flows
Right under the pasture! And then... well, who knows?

It might go along, down where no one can see,
Right under State Highway Two-Hundred and Three!

Right under the wagons! Right under the toes
Of Mrs. Umbroso who's hanging out clothes!

It might keep on flowing... perhaps... who can tell?
Right under the people in Sneeden's Hotel!

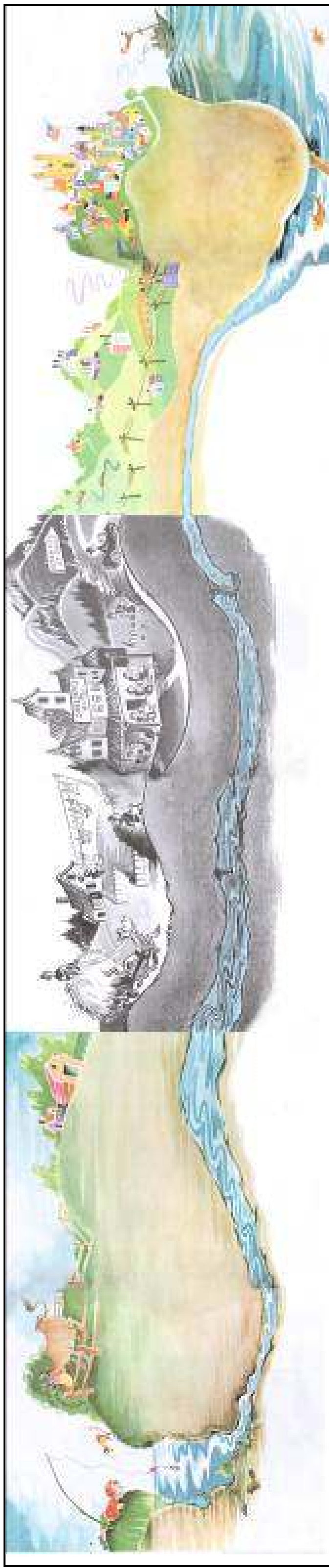
Right under the grass where they're playing croquet!
The under the mountains and far, far away!

This might be a river,
Now mightn't it be,

Connecting
  McElligot's
    Pool
      With
        The
          Sea!

Then maybe some fish might be swimming toward me!

The map, which requires six pages in the book, we'll reduce to fit on the next page.



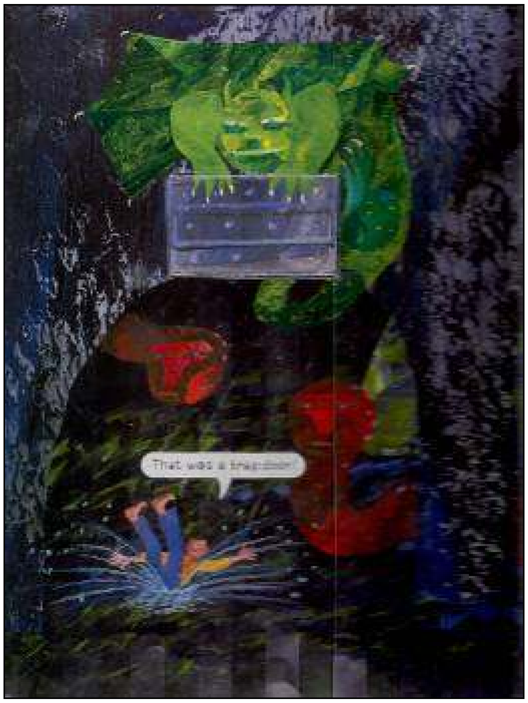
McElligot's Pool

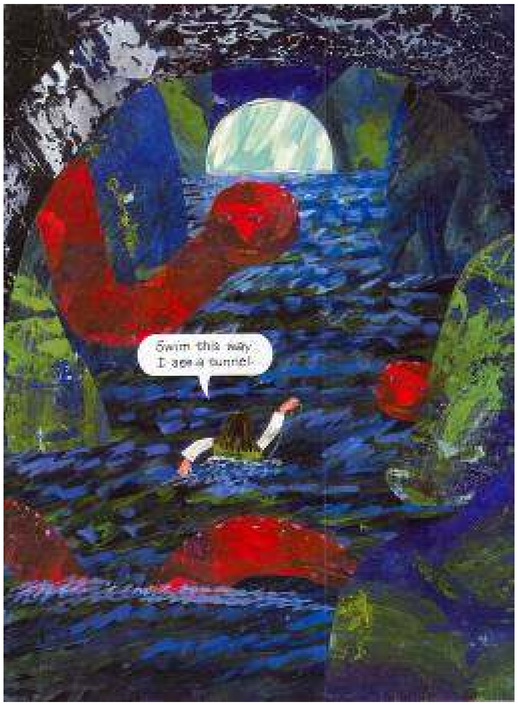
On that uplifting rhyme, the fanciful geology and thoughts of a wonderful underground river flowing from such a small pond, we'll bid adieu to the poets.

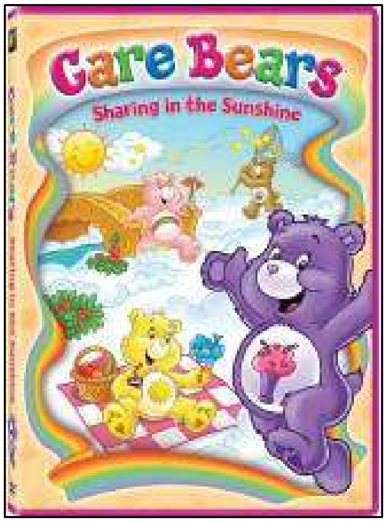
What Watch Out! A Giant! (1978) by **Eric Carle** lacks in words,

That was a trap door!
Swim this way, I see a tunnel!,

it makes up in artwork.


That was a trap door!


Swim this way. I see a tunnel.



A video is of course not a picture book, but as more and more works for children are marketed -- and for that matter, available from the library -- in both paper and electronic forms, we'll be inclusive.

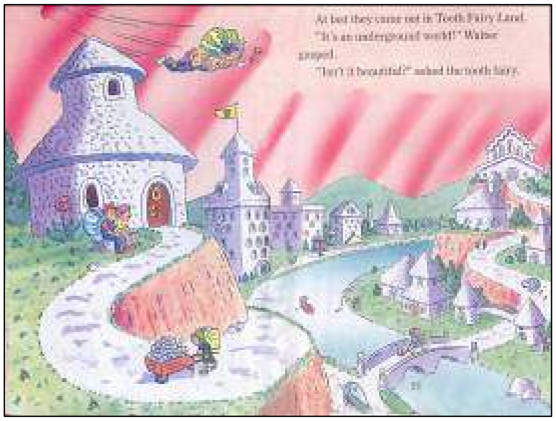
In the 1985 Care Bears video, Sharing in the Sunshine, our furry friends must find a way for Patti's dad to make it to her pageant on time. Professor Coldheart dumps concrete from his airplane so little Suzy can roller-skate everywhere and Jill's pals get trapped in a cellar because she sent them on a phony treasure hunt. And then Joey and Elaine discover an underground river and get stuck in a cave.

Whatever the problem, the Care Bears are there to lend a paw.

No Tooth, No Quarter by (1989) by **Jon Buller** and **Susan Schade** is about a tooth fairy.

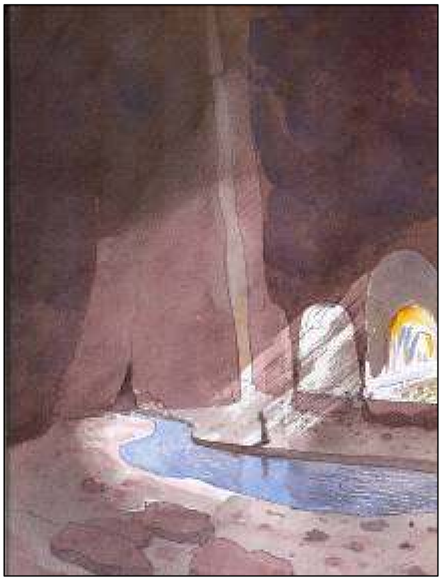
> *At last they came to Tooth Fairy Land.*
>
> *"It's an underground world!" Walter gasped.*
>
> *"Isn't it beautiful?" asked the tooth fairy.*

As can be seen, the underground Tooth Fairy Land contains a river.



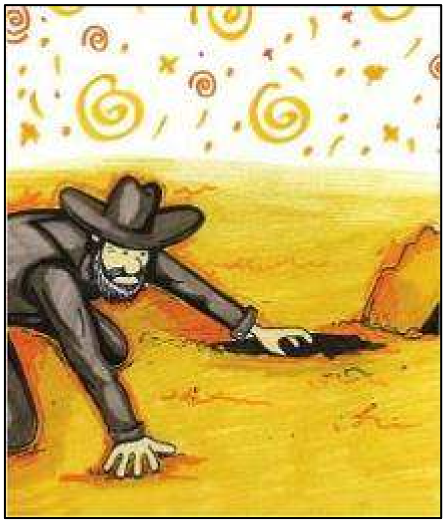
In the legend Persephone (1994) told by **Warwick Hutton**, having eaten six pomegranate seeds in Hades's cavernous domain where only a sinuous underground river and a few forlorn pomegranate trees relieve the austerity, the earth goddess Persephone is consigned to spend half of each year there, during which months the earth darkens.

A lone shaft of light penetrates a deep, gray chasm.

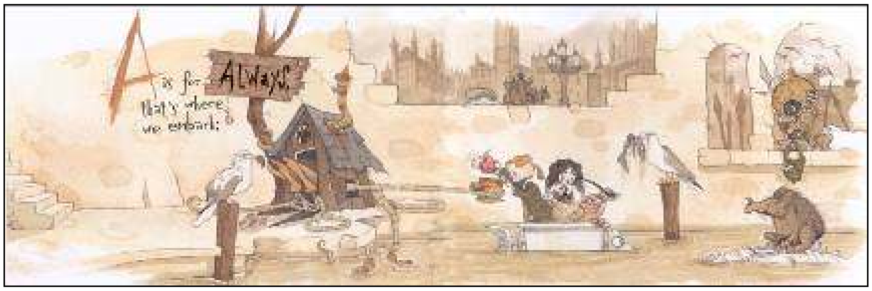


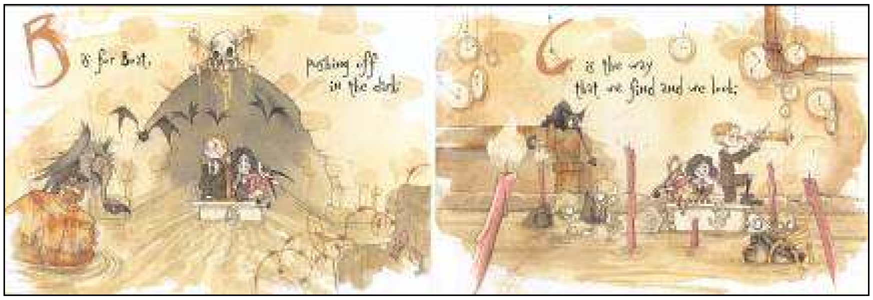
From The Rodeo (2007) by **David W. Canterbury**,

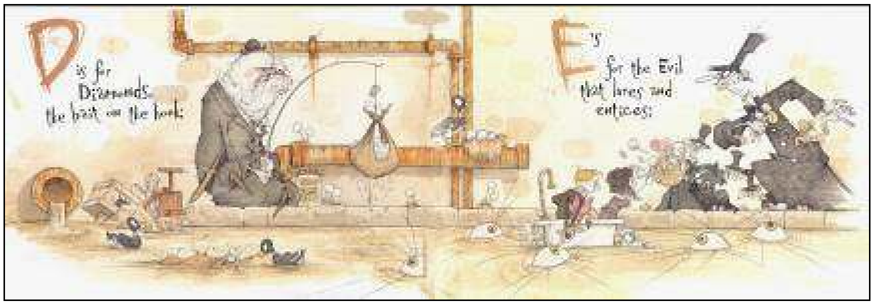
> *Cowboy Bob took a deep breath and walked toward the stranger. As Cowboy Bob grew close, he yelled, "Hey there!"*
>
> *The stranger was startled and jumped back and then fell right into the hole. Cowboy Bob ran over and discovered the hole was actually the opening to the cave of the underground river.*
>
> *Cowboy Bob looked into the cave and could only see and hear the rushing water of the underground river. Suddenly there was a yell. "Help!"*

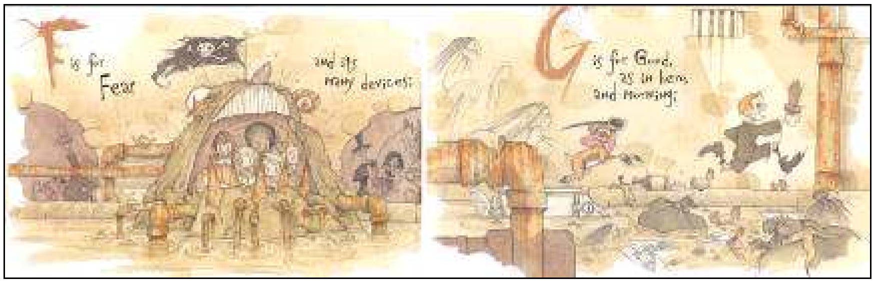


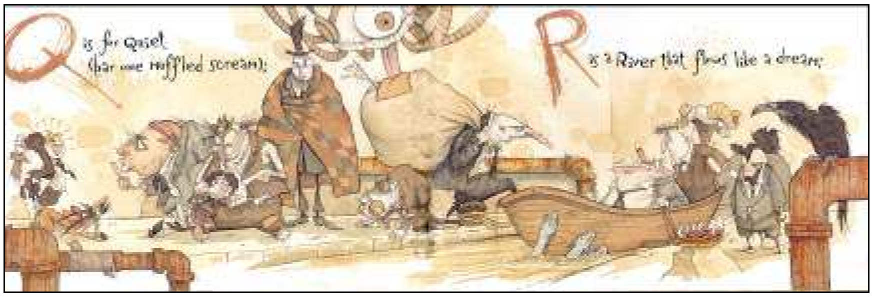
The Dangerous Alphabet (2008) by **Neil Gaiman** contains rhyming couplets, each an alliterative and ominous interpretations of what each letter stands for. The tale is a disturbing adventure with a sepia-toned Dickensian setting, in which two children and their pet gazelle venture though an underground river surrounded by monsters and villains. We show just some of the illustrations.

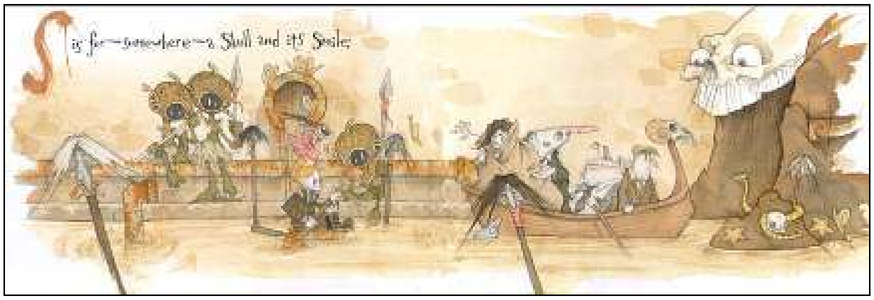

A is for Always, that's where we embark;
Always

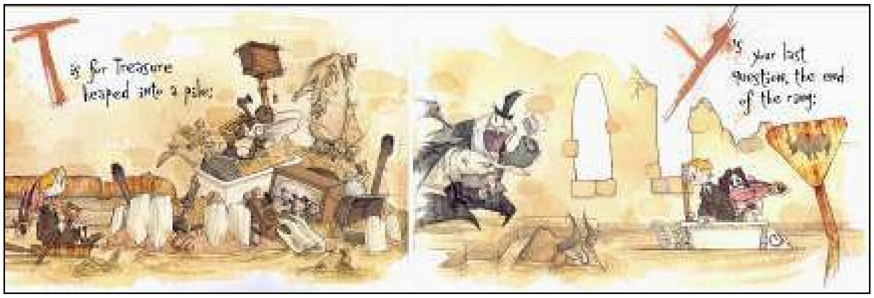

B is for Boat, pushing off in the dark
C is the way that we find and we look;


D is for Diamonds, the bait on the hook;
E's for the Evil that lures and entices;


F is for Fear and its many devices;
G is for Good, as in hens and morning;


Q is for Quiet (bar one muffled scream);
R is a River that flows like a dream;


S is for—somewhere—a Skull and its Smile;


T is for Treasure heaped into a pile;
Y's your last question, the end of the romp;

We've barely dipped into the pool of picture books incorporating underground rivers into the settings -- the bibliographic tools to search by illustration just aren't there -- but we've established that such dark waters are regularly employed.

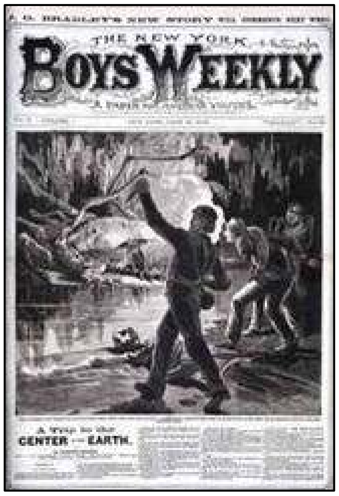
Literary criticism of adult fiction (e.g., works cited in the previous two chapters) is rife with interpretations of such settings, some of which we've mentioned and others woven into chapters ahead, Chapter 37, Achluohydrophobia.

We need not opine to great degree about underground rivers in children's picture books, however. Kids understand without our interpretation. If they didn't grab the essence of such settings, they'd not ask us to read them the books time and time again. Those of us prone toward analysis of such matters, however, can await Chapter 90, Why Do We Believe What We Believe, our journey's ultimate disembarkation.

CHAPTER 19
THE STRATEMEYER BOYS CLUB SERIALS

Boys Club Literature

We've bracketed the spectrum of underground river fiction. Chapters 16 and 17 recognized works well-respected in modern literature. Chapter 18 sampled picture books for young children.

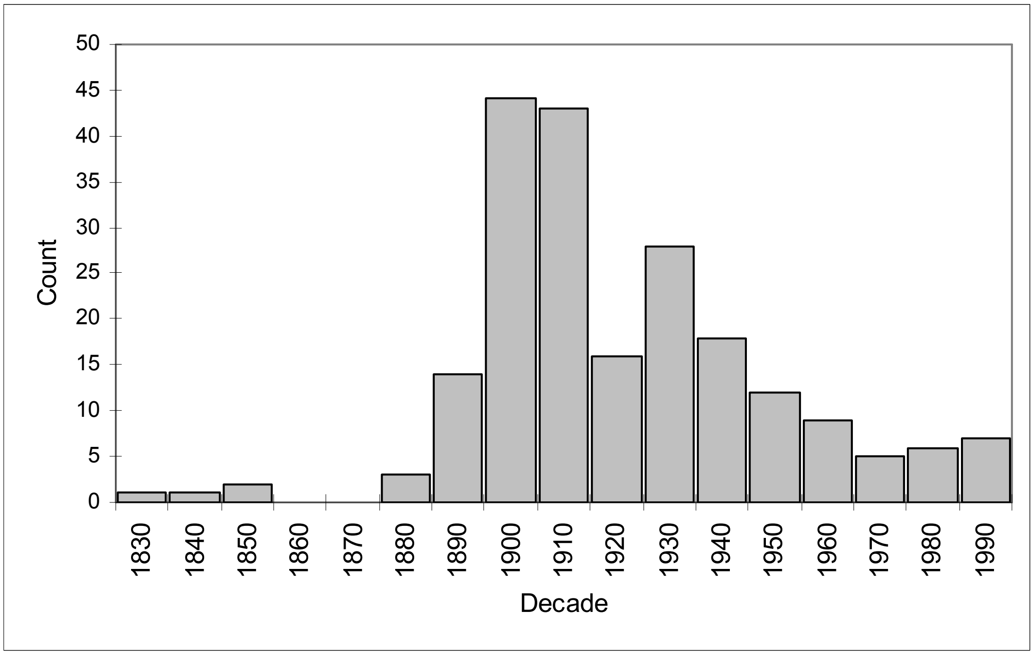


We'd be remiss to ignore the larger portion of underground river literature, that from the ranks of authors who aimed at an intermediate demographic, juvenile readers -- juvenile males, for most part, more likely than girls to pick up a swashbuckling subterranean adventure.

We move to what we'll call "Boys Club" literature, as illustrated by the underground river illustration of Howard De Vere's piece about Mammoth Cave, "A Trip to the Center of the Earth" in the New York Boys Weekly (1894).

Boys Club plots and characterizations tend toward the formulaic -- fast-paced adventures in exotic environments. Casual racism and sexism can be jarring. But, by golly, the boys do have nifty adventures.

The distribution of new releases over time reveals the Boys Club heyday. As such literature tended to be inexpensively bound, shoddily treated and dismissed by archivists, who knows how many like works have been completely forgotten?

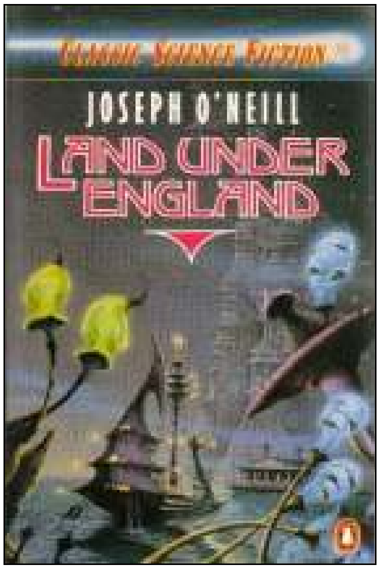


Lost World Books in English, 1800-2000

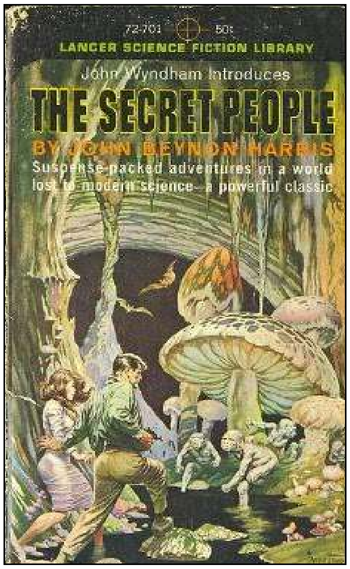
Boys Club lost world fiction (a larger grouping than underground adventures, but closely akin and well cataloged by modern scholars) exploded in the late 1800s, an era when invention and global exploration promised great scientific advancement. Every boy wanted to become a part of it. Boys Club fiction of recent vintage is often set in such places as Machu Picchu, the Congo or the Himalayas to couch the tale in nostalgic pastiche.

Of the 1500 books of the genre involving lost worlds, some 200 can be identified by title or summary as being set underground. An exhaustive read would be required to enumerate how many of these 200 subterranean worlds include riverine watercourses, but the proportion would be high. They are "worlds," after all, and as we will come to see, authors of juvenile fiction tend to transport that with which we are familiar to their more exotic geographies.

Below are a few 1935 cover illustrations showing underground waters.


CLASSIC SCIENCE FICTION
JOSEPH O'NEILL
LAND UNDER ENGLAND

Joseph O'Neill
Land Under England (1935)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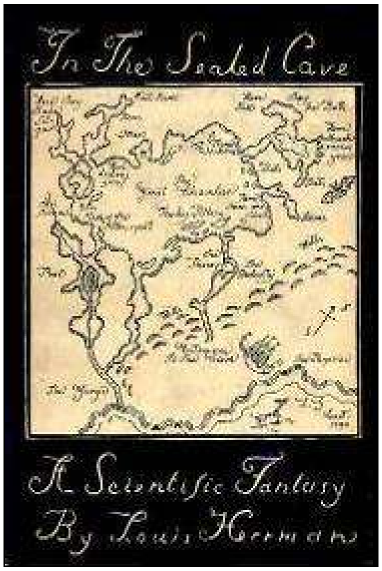
50¢
LANCER SCIENCE FICTION LIBRARY
John Wyndham Introduces
THE SECRET PEOPLE
BY JOHN BEYNON HARRIS
Suspense-packed adventures in a world lost to modern science - a powerful classic

John B. Harris
The Secret People (1935)


In The Sealed Cave
A Scientific Fantasy
By Louis Herrman

Louis Herrman
In the Sealed Cave (1935)

This and the following three chapters will take brief looks at a large number of Boys Club adventures involving underground rivers. We'll begin with the works of one particular publishing operation that chronicled copyrighted Boys Club heroes over more-or-less the same terrain, volume after volume. We'll then look at similar serials spawned elsewhere. Then we'll mention a number of Boys Club books written in more of a stand-alone manner. And then we'll deal with stories written for the biggest Boys Club of all, the Boy Scouts.

That's a lot of Boys Club literature, but we'd not properly appreciate underground rivers without such a broad foundation.

Girls Club underground river literature is a shorter topic, only a chapter's worth in total.

The Stratemeyer Syndicate

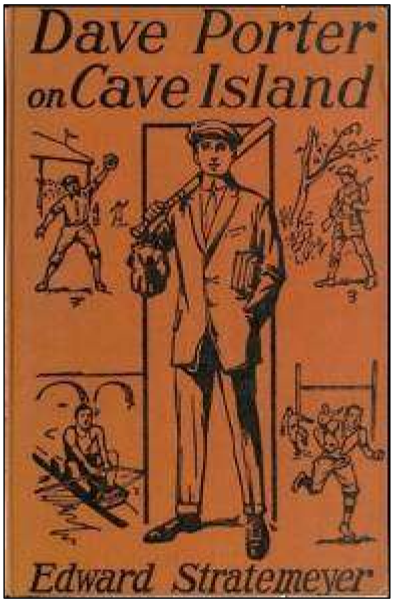
The Stratemeyer Syndicate, a book-packaging firm of juvenile literature founded by in 1905 by Edward Stratemeyer, is best remembered for producing the Bobbsey Twins, Hardy Boys, Nancy Drew, Rover Boys and Tom Swift series.

The syndicate produced over 1200 books in 125 separate series under some 100 pseudonyms. One person wrote an outline for a story or series of stories, another wrote the story itself, and often another refined the work.

Series production was overseen by Stratemeyer until his death in 1930, and the rights to all its series were sold to Simon and Schuster in 1984.

Edward Stratemeyer, the Author

Edward Stratemeyer probably penned 150 books himself, his first success being the 30-volume Rover Boys begun in 1899 under the pseudonym Arthur M. Winfield. Stratemeyer affixed his actual name, however, to the 15-volume Dave Porter series begun six years later. We'll quote a few paragraphs about an underground river.


Dave Porter on Cave Island
Edward Stratemeyer

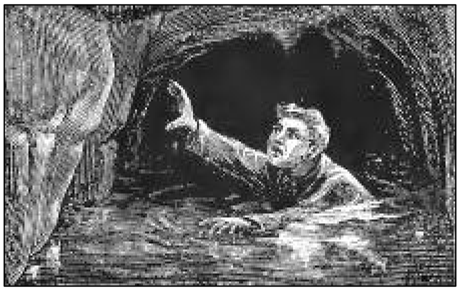
Dave Porter on Cave Island, or A Schoolboy's Mysterious Mission (1913)

> *"Whe- where are we?" asked Merwell, and there was a shiver in his tone.*
>
> *"Down at the bottom of that hole." Dave tried to pierce the darkness. "Looks like some underground river to me."*
>
> *"The water is salt."*
>
> *"Then this place must connect with the ocean."...*
>
> *"Oh, what shall we do?" groaned Merwell, after they had attempted to climb up and had failed. "We are caught like rats in a trap!"*
>
> *"Perhaps we'll have to swim for it," answered Dave." This water is very salt, which proves it comes from the ocean. Moreover, it is gradually going down, showing it is affected by the tide. Let us follow the stream for a short distance and see where it leads to."*
>
> *Merwell demurred, but he did not want to remain behind alone in the semi-darkness, so he followed Dave, and both waded and swam a distance of several hundred feet. Here the underground river made a turn around the rocks, and both boys were delighted to see a streak of sunlight resting on the water...*
>
> *Soon the pair reached a break in the cave. On either side were walls of rocks, uneven and covered with scanty bushes and immense trailing vines. The opening was about a hundred feet in length, and beyond it the stream of salty water plunged into another cavern, undoubtedly on its way to the ocean...*
>
> *I hate it underground!" And Merwell shivered. "Besides, it's cold," he went on, to cover up the tremor in his voice.*

Capt. Ralph Bonehill

Edward Stratemeyer also wrote as Capt. Ralph Bonehill, but so may have contract writers subsequently in his enterprise.

In Bonehill's The Three Young Ranchmen, or Daring Adventures in the Great West (1901), three boys encounter a genuine grizzly, a wolverine, discover of a gold mine, horse thieves, and an explore an underground river on a single Idaho ranch.



From Bonehill's Four Boy Hunters, or The Outing of the Gun Club (1906),

> *"Let us try to find some other way out."*
>
> *They walked back and forth in the cave and then, by common consent, sat down on some flat rocks to consider the situation.*
>
> *Nobody felt like joking, for all felt the seriousness of the situation.*
>
> *"That water must come to the surface somewhere," said Snap. "But it may be a good distance from here."*
>
> *As they were wet to the knees, one after another got down in the stream and examined the rocks. Some thought they saw daylight under the water beyond the rocks, but nobody was sure.*

FOUR BOY HUNTERS
CAPTAIN RALPH BONEHILL
BOY HUNTERS SERIES

From Bonehill's preface to When Santiago Fell, The Adventures of Two Chums (1899), the last of the 9-volume Flag and Frontier series,

> *My object in writing this story was to present to American lads a true picture of life in the Cuba of today, and to show what a fierce struggle was waged by the Cubans against the iron-handed mastery of Spain previous to the time that our own glorious United States stepped in and gave to Cuba the precious boon of liberty..*

Describing a fictional Cuban underground river,

> *Putting my hand up, I learned that the rocky ceiling was not over two feet above the surface of the water, and the distance between the two was gradually but surely growing less!*
>
> *I was horrified over the discovery that I had made. Here I was, in absolute darkness, hemmed in by water and rocky walls, and drifting rapidly I knew not whither.*

WHEN SANTIAGO FELL
BY CAPTAIN RALPH BONEHILL

> *In my terror I cried aloud, but only echo answered me -- a peculiar echo which made me shiver from head to foot.*
>
> *On and on, and still on, was I dashed by the underground current, which seemed to grow more powerful as I advanced, until my head grazed repeatedly against the wall over me, and I felt like giving myself up for lost. Oh, how bitterly I regretted the curiosity which had led me to explore the cavern in which chance had so strangely placed me!*
>
> *But now what was this -- a light? At first I could scarcely believe the evidence of my senses. There was a bright flash -- then total blackness again.*
>
> *What could it mean? Perhaps I was dreaming -- or the fearful situation had turned my brain. Then came a second flash and a revelation.*
>
> *It was the lightning from without, shining through some opening into the waters under and around me! I was nearing the outer world. Oh, for a breath of fresh air again!*
>
> *Even as the thought crossed my mind, my head struck the rocky ceiling again, and under I went, to find that I could not come up, the water now rising to the very rocks. But a stronger light could be seen, and I dove along, came up once, twice -- and then emerged into the open air with a splutter and a gasp, on the verge of exhaustion.*

> *The underground stream emerged at the very base of the mountain, and on both sides were level stretches of swamps, covered with rushes and other tropical growths. Swimming for the nearest bank, I drew myself up and fell on my breast, too worn out to stand.*

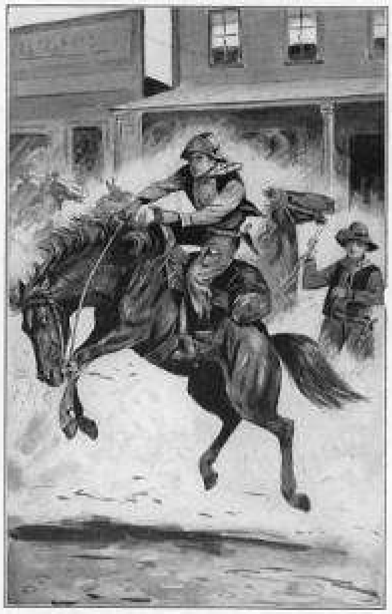
Capt. James Carson

We always know where this pseudo-officer's Saddle Boys are saddling up.

The Saddle Boys of the Rockies (1913)
The Saddle Boys in the Grand Canyon (1913)
The Saddle Boys on the Plains (1913)
The Saddle Boys at Circle Ranch (1913)
The Saddle Boys on Mexican Trails (1915)

From The Saddle Boys of the Rockies, or Lost on Thunder Mountain,

> *Frank went on, "but if that flood just happened to break loose while we were between those high walls we'd have an experience that would be fierce, let me tell you!"*
>
> *"But then, it may not come for hours yet?" remonstrated the Kentucky boy, who was anxious to be once again in the saddle, and leaving the haunted mountain well in the rear.*
>
> *"Oh! for that matter, it may not come at all," Frank went on.*
>
> *"Although Smith did say he really believed that this was going to finish the old geyser, which he believed empties into one of those queer underground rivers we know are to be found all through the Southwest. And Smith ought to know something about it, for he's been watching this business a whole year now, from close quarters."*
>
> *"Good gracious! Do you mean that the old geyser has turned into a river, and will keep on running like this right along?" cried the other.*



THE BIG POWERFUL BLACK ACTED AS THOUGH HE HAD GONE WILD.

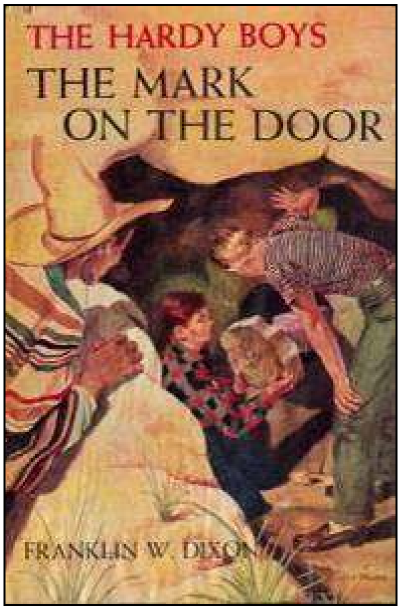
The Saddle Boys of the Rockies Page 22

> *"Looks that way to me," Frank replied. "It is a great big siphon, and once started, the water that has for centuries been wasting in some underground stream is now flowing down this canyon. Perhaps long ago it did this same thing, till some upheaval -- an earthquake it might have been -- turned things around."*

We've also the syndicate's Captain Quincy Allen, but in none of this officer's eight Outdoor Chums adventures do the chums stumble upon an underground river.

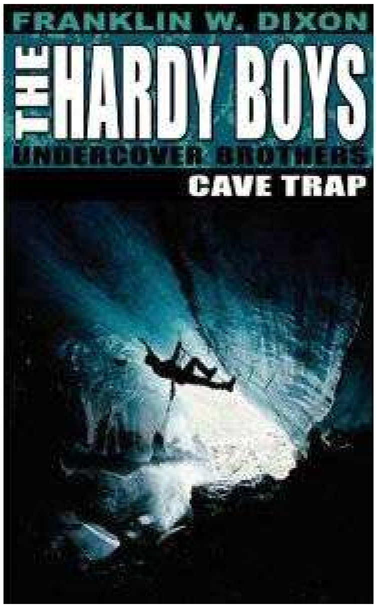
Franklin W. Dixon

Stratemeyer's strict rules for his publications required that the youthful heroes remain youthful. Franklin W. Dixon's -- Hardy Boys series remains in perpetual publication, 190 and counting, the boys still at their 1926 age. Scores of authors can claim to be Dixon.



THE HARDY BOYS
THE MARK ON THE DOOR
FRANKLIN W. DIXON

In The Hardy Boys, The Mark on the Door (1934), Frank and Joe investigate a mystery more dangerous than any before. A mark on the door leads the boys to Mexico in search for a kidnapped scientist. In following the clues to a gang of desperados, they discover the deadly secret. To escape from the mountain hideout, the Hardys are swept towards their doom in the swirling currents of an underground river.



FRANKLIN W. DIXON
THE HARDY BOYS
UNDERCOVER BROTHERS
CAVE TRAP

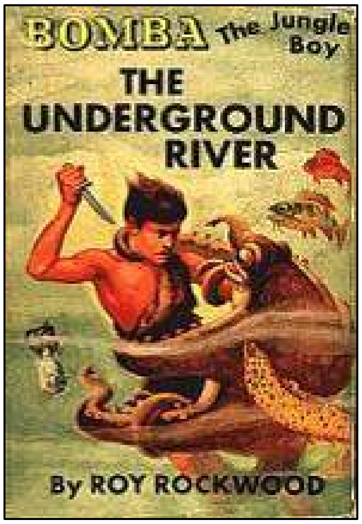
In Cave Trap (1996), the Hardys join a team of spelunkers in Cathedral Cave State Park, a Mammoth Cave surrogate. Stumbling upon an uncharted cavern, the boys encounter murderers, ancient booby traps, ill health, an enemy among the team and a vicious whirlpool.

Roy Rockwood

Roy Rockwood was the house pseudonym for Stratemeyer's 20-book Bomba series, 1905-1937, tales of a lad dwelling deep in the Amazon with a half-demented professor.

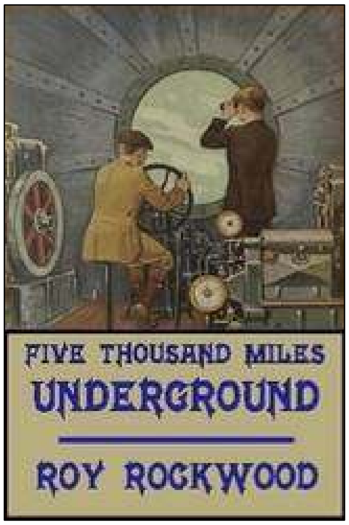
In Bomba the Jungle Boy, The Underground River *(*1930), after a jaguar attack and an opera, Bomba and friend stumble into a deep cavern through which flows an underground river. Caught in a subterranean flood, the two discover a series of shelves above the tunnel floor and step by step, the two climb as the relentless waters pursue.

As any Boys Club would like an author with the name Roy Rockwood, the authorship turned out the Dave Fearless series, the Dave Dashaway series and the Speedwell Boys series.



BOMBA The Jungle Boy
THE UNDERGROUND RIVER
By ROY ROCKWOOD

From Rockwood's Five Thousand Miles Underground, or The Mystery of the Centre of the Earth (1908)



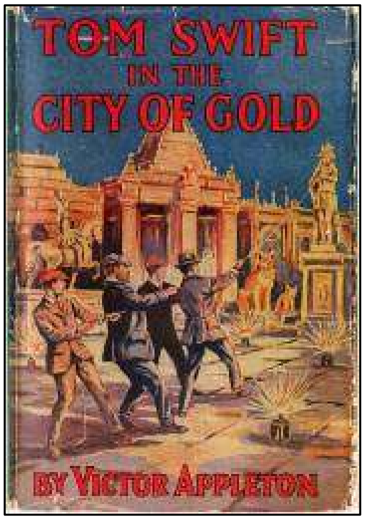
> *With a tremor the Mermaid left the surface of the inner earth and went sailing upward toward the-- well it wasn't exactly the sky, but it was what corresponded to it in the new world, though there were no clouds and no blue depths such as the boys were used to. At all events the Mermaid was flying again, and, as the adventurers felt themselves being lifted up they gave a spontaneous cheer at the success which had crowned their efforts.*
>
> *The ship went up several hundred feet, and then, the professor, having brought her to a stop, sent her ahead at a slow pace. He wanted to be sure all the apparatus was in good working order before he tried any speed.*
>
> *The Mermaid responded readily. Straight as an arrow through the air she flew...*
>
> *"Well, this is almost as good as being on the regular earth!" exclaimed Jack.*
>
> *"It's better," put in Mark. "We haven't seen half the wonders yet. Let's open the floor shutter, and see how it looks down below."*
>
> *He and Jack went to the room where there was an opening in the floor of the ship, covered by heavy glass. They slid back the steel shutter and there, down below them, was the strange new, world they had come to, stretched out like some big map*
>
> *They could see mountains, forests, plains, and rivers, the water sparkling in the colored light. Over green fields they flew, then across some stretches where only sand and rocks were to be seen. Faster and faster the ship went, as the professor found the machinery was once more in perfect order...*
>
> *From the centre of an immense mound of rock and earth there spouted up a great column of water, three hundred feet or more, as straight as a flag staff. It was about ten feet in diameter, and at the top it broke into a rosette of sparkling liquid, which as the varicolored lights played on it, resembled some wonderful flower.*
>
> *"It's a great geyser!" the professor exclaimed. "We have come to a place like Yellowstone Park. We must be very careful. The crust may be very thin here, and let us down into some boiling spring."...*
>
> *All that afternoon they sailed, the country below them unfolding like a panorama. They passed over big lakes, sailing on the surface of some, and over rivers, and vast stretches of forest and dreary plains...*

After the requisite adventures, the underworld is exited under the instruction of the professor -- a character often present in Boys Club literature. At the end,

> *Their cylinder, which might now be termed a boat, was floating on the great Atlantic. The blue sky was overhead and the air of the sea fanned their cheeks.*

Victor Appleton

Victor Appleton is the collective pseudonym for the author of more than 100 Tom Swift books, the adventures of the likable and formidable teenage inventor. Tom's challenges are resolved with hard work, original thought, respect for others and of course, good manners.



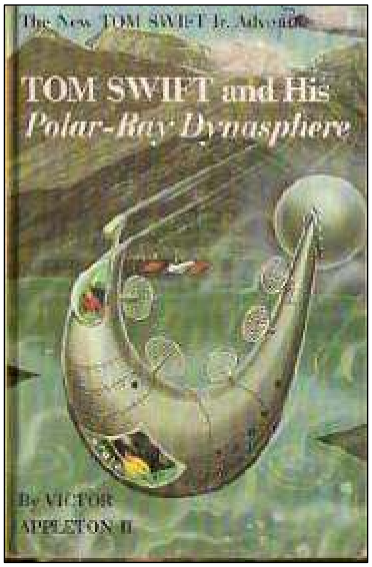
Tom Swift in the City of Gold, or Marvelous Adventures Underground (1912)

> *"A river! It's an underground river and we can't go any further! We're blocked!"*
>
> *They saw rushing along, between two walls of stone, a dark stream which caused the roaring sound that had come to them. The tunnel was cut squarely in two by the stream, which was at least thirty feet wide, and how deep they could only guess. Swiftly it flowed on, its roar filling the tunnel.*
>
> *"Well, I guess this is the end of it," remarked Ned ruefully, as they stood contemplating the roaring stream by the gleam of their electric flash lamps... "But it seems to me as if this river isn't a natural one -- I mean that it flows along banks of smooth stone, just as if they were cut for it, a canal you know."*
>
> *"Don't you see," continued Ned, "that this river hasn't always been here."*
>
> *"Bless my gaiters!" gasped Mr. Damon, "what does he mean? The river not always been here?"*
>
> *"No," proceeded Tom's chum. "For the ancients couldn't have cut the channel out of stone, or made it by cementing separate stones together while the water was here. The channel must have been dry at one time, and when it was finished they turned the water in it... [I]f the river was turned aside from this channel once it can be done again... We've got to shut that stream of water off, or turn it into some other channel, then we can cross, and keep on to the city of gold."*
>
> *Eradicate, who was searching as eagerly as the others, went back a little, flashing his lamp on every square of stone. Suddenly he uttered a cry.*
>
> *"Look yeah, Massa Tom! Heah's suffin' dat looks laik a big door knob. Maybe yo' kin push it or pull it."*

Racism seems to be part of the writing formula.

> *In a flash Tom did so. For a moment no result was apparent, then, from somewhere far off, there sounded a low rumble, above the roar of the black stream.*
>
> *"It's going down!" he yelled, capering about. "Now we can go on!"*
>
> *"Dish suah am a mighty long tunnel," remarked Eradicate. "Dey ought t' hab a trolley line in yeah."*

In Tom Swift and His Polar-Ray Dynasphere (1964), our lad takes on plumbing problems.



> *"But will not more water be welling up all the time from the underground river?"*
>
> *"Not if I plug the inlet first," Tom replied quietly. "After the water has been vaporized, I can clean out all the poisonous sediment and plant growth with a machine of mine called a Spectromarine selector. Then I'll remove the plug and allow the lake basin to fill up again -- with pure, fresh water."*

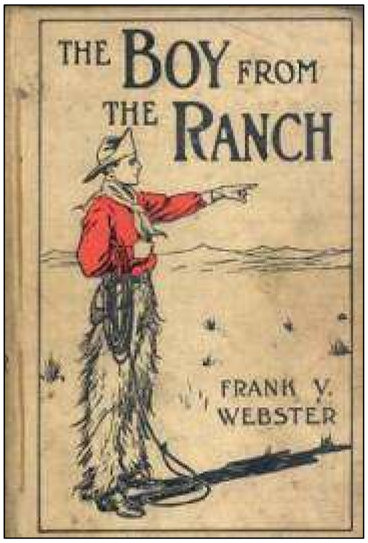
Fortunately he'd packed along his Spectromarine selector!

Appleton also churned out seven volumes of Motion Picture Chums, 15 of Moving Picture Boys, and 17 of Movie Boys, leaving others in the Stratemeyer corral to write the Motion Picture Comrades, but the movie formula failed to include underground rivers.

Frank V. Webster

Webster is credited with some 25 Boys Club volumes, but as the characters changed, the result is simply known as the "Webster Series."

A Boys Club enjoys a good chuckle. From Webster's The Boy from the Ranch, or Roy Bradner's City Experiences (1909),



> *"Excuse me, stranger," he began, in his broad western tones. "But how long is this tunnel, anyhow?"*
>
> *"Tunnel? This ain't no tunnel!"*
>
> *"No? What is it then? It's a pretty good imitation. Looks like an underground river that has gone dry."*
>
> *"Why, this is the subway."*

The passing mention of an underground river in An Undivided Union: (1899), a Civil War novel, merits mention for its authorship.

> *Crawfish Springs was a most beautiful spot, a typical scene for a landscape painter. The spring was really the outlet for a subterranean river, and flowed forth between beautiful hills covered with trees and flowering bushes. It was on the estate of a widow, Mrs. Gordon, whose fine brick mansion stood not far away. In the vicinity of the spring was the house of Lowry, Second Chief of the Cherokees, and it was here that the Army of the Cumberland had, for the time being, established its hospital.*

The book's credited to both Edward Stratemeyer and **Oliver Optic**, an admiral pseudonym of **William Adams**, a non-syndicate writer. What's surer than the work's bibliographic roots is the fact that, once again, there's an underground river.

And we've just skimmed the Stratemeyer surface. Holding strictly to like-titled series, there are also the

The Radio Boys by Allen Chapmen
The Motor Boys and the Racer Boys by Clarence Young
The Fairview Boys by Frederick Gordon
The Pioneer Boys by Harrison Adams
The White Ribbon Boys by Raymond Sperry, Jr.
The Rushton Boys by Spencer Davenport
The Y.M.C.A. Boys by Brooks Henderley
The X Bar X Boys by James Cody Ferris
The Air Service Boys by Charles Emory Beach

Were we to plough through the lot, we'd expect to find mostly the same underground rivers. A stable of writers working under a catalog of pseudonyms produces a plethora of predictably narrow escapes.

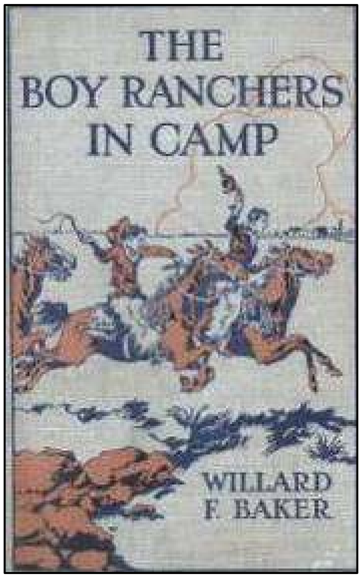
We'll see more of the Stratemeyer Syndicate in Chapter 23, Girls, Too!, but there we'll encounter works less penetrated by underground rivers because girls tend to be more intelligent about exploring such waterways.

CHAPTER 20

MORE BOYS CLUB SERIALS

As prolific as was the Stratemeyer Syndicate, that organization was by no means the sole source of Boys Club serials. This chapter notes such series produced by other publishers, some of the sets likewise hack-written to formula specification, others the product of a consistent author who may yet be familiar to us. The chapter to follow will alphabetically gather together Boys Club tales not written as sets.

Willard F. Baker

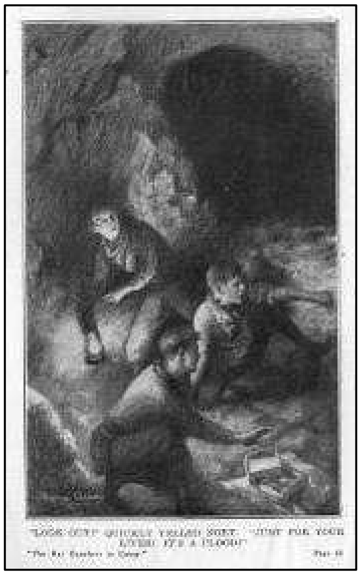


According to the publisher's advertisement, Willard Baker's Boy Ranchers series are,

> *Stories of the great west, with cattle ranches as a setting, related in such a style as to captivate the hearts of all boys. In each volume there is, as a background, some definite historical or scientific fact about which the tales hinge.*

In The Boy Ranchers in Camp, or The Water Fight at Diamond X (1921), two eastern boys visit their cousin, whose father owns the Diamond X ranch, and become involved in a mystery involving a mysterious river.

> *"Doesn't that sound like rushing water?" asked Bud.*
>
> *"Yes," agreed Dick, after a moment of intentness; "it does."*



> *"Look out!" quickly yelled Nort. "It is water, and on the rush, too! Jump for your lives! It's a flood!" and making a grab for one of the lanterns, that they might not be left in total blackness, he sprang toward the rocky side of the tunnel, an example followed by his companions.*
>
> *And the rush of waters filled the underground cave with a mighty, roaring sound.*
>
> *Stumbling, slipping, sliding, half-falling, bruising themselves on the sharp rocks, but ever leaping forward toward the sides of the tunnel, and away from the depressed centre down which they could see the rush of waters coming, the boy ranchers at last managed to reach the granite wall. Nort had succeeded in grabbing up one of the lanterns, but there was no time for Dick or Bud to take one, and the food had to be abandoned.*
>
> *"Climb up! Climb up, if there's a ledge!" shouted Bud. "We'll be drowned if we can't get above the water!"*
>
> *He had, somehow or other, brought up in the rear. Though he did not admit it, this was because he had shoved his cousins ahead of him, hoping thus to enable them to gain a safe place.*

> *And as Nort and Dick glanced back they saw, in the gleam of the one lantern left alight, a white mass of water bearing down on them, and, seemingly, filling the tunnel from wall to wall, as it rushed foaming and murmuring onward.*
>
> *It was as though a dam had suddenly burst, or some obstruction had been removed, allowing the pent-up waters to rush along the accustomed channel. And if you have ever noticed a dammed-up stream, say in some gutter, thus quickly released, you can imagine what happened on a larger scale in the tunnel where the boys were.*

Note the last sentence's plug for scientific curiosity, a Boys Club strong point.

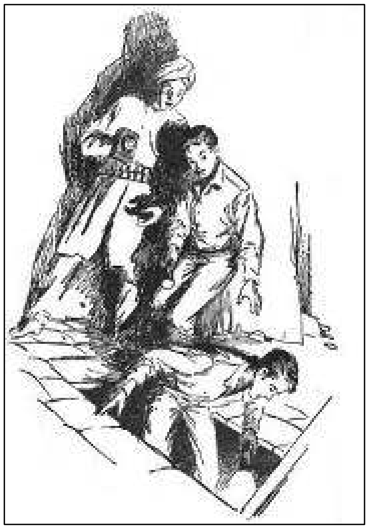
For similar adventure, we can turn to Baker's

The Boy Ranchers, or Solving the Mystery at Diamond X (1921)
The Boy Ranchers on the Trail, or The Diamond X After Cattle Rustlers (1921)
The Boy Ranchers Among the Indians, or Trailing the Yaquis (1922)
The Boy Ranchers at Spur Creek, or Fighting the Sheep Herders (1923)
The Boy Ranchers in the Desert, or Diamond X and the Lost Mine (1924)
The Boy Ranchers on Roaring River, or Diamond X and the Chinese Smugglers (1926)
The Boy Ranchers in Death Valley, or Diamond X and the Poison Mystery (1928)
The Boy Ranchers in Terror Canyon, or Diamond X Winning Out (1930)

John Blaine

The Rick Brant Science-Adventures were by John Blaine (pseudonym of Harold L. Goodwin), of which we'll cite The Caves of Fear (1951), an atomic-age thriller.

Using infra-red goggles to explore the caverns beneath the Himalayas, Rick Brant, son of noted scientist Hartson Brant, and Rick's buddy, WWII vet Scotty Scott, come across both the Black Buddha and an underground lake of heavy water. The two must stop the bomb-making material from falling into the wrong hands.



> *The rocky shore of the underground lake receded rapidly. Rick stopped rowing and turned, switching the infrared light toward the direction in which he was heading. He could see the opposite shore now, but dimly. Knowing that the infrared light was effective at eight hundred yards, he estimated the lake to be about twelve hundred yards wide. That was over three-fifths of a mile.*
>
> *When he shot the light up and down the lake, he saw nothing but the black water. That meant the lake was more than sixteen hundred yards long. He turned the light upward and surveyed the ceiling. It was irregular, varying in height from a dozen feet to over two hundred. In one place, the ceiling came down to within a few feet of the black water.*
>
> *It was an eerie place. Rick's quick imagination turned him into the mythical Charon, who ferried the dead across the River Styx into Hades.*
>
> *Then suddenly he realized it wasn't as dark as he had expected!*
>
> *There was a faint luminous quality that outlined the shore of the lake.*
>
> *He studied the line of demarcation, then guessed that the faint luminosity must come from microscopic plant or animal life that clung to the rock underwater. Sea water had a phosphorescence sometimes for the same reason.*

> *His eyes followed the faint line up the shore in the direction he had been traveling. The silver phosphorescence turned a faint yellow. Almost out of the range of his vision the yellow was picked up by the water, like the dimmest moonlight.*
>
> *He studied it for long minutes, trying to figure out the reason for the phenomenon, then he almost leaped out of his skin.*
>
> *"It is true," he continued, "that heavy water has a tendency to sink. Naturally enough, since it is heavier. But for enough to form on the bottom of a body of water, there would have to be great depth and complete calm. Any current would stir the water up and the heavy water would merge with the normal once more."*
>
> *"In other words, you need a lake like this one."*

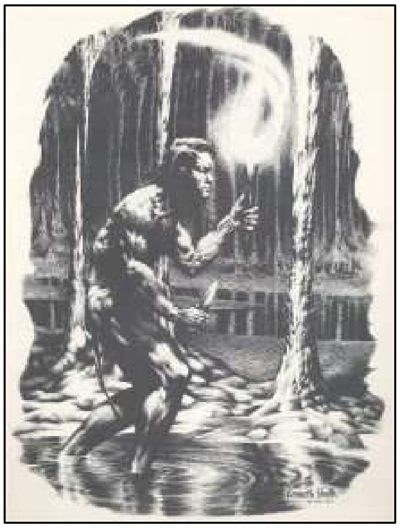
Edgar Rice Burroughs

What Burroughs' prose lacked in quality, he made up in quantity. "I write to escape poverty," he noted of his 68 titles, 25 of which featured Tarzan. And escape poverty he did.

Burroughs' Pellucidar Series is set in the hollow earth.

At the Earth's Core (1914)
Pellucidar (1915)
Tanar of Pellucidar (1929)
Tarzan at the Earth's Core (1929), a crossover, bringing the Ape Man himself into the adventure
Back to the Stone Age (1937)
Land of Terror (1944)
Savage Pellucidar (1963, posthumously)

The illustration to the right invokes some of Pellucidar's hydrologic flavor.



By the next novel, Pellucidar (1915), visitors from above have grandly made themselves indispensable to the subterranean world. A la Twain's A Connecticut Yankee in King Arthur's Court (1889), a resourceful American turns the tide of battle with the militarization of underground waters.

> *The upshot of it was that the boat of which the Sagoth speaker was in charge surrendered. The Sagoths threw down their weapons, and we took them aboard the ship next in line behind the Amoz.*
>
> *Thus ended the first real naval engagement that the Pellucidarian seas had ever witnessed.*

Burroughs' The Land That Time Forgot (1918) is a Darwinian story set on a mysterious island near the South Pole where dinosaurs survive. While this tale is not set in Tarzan's underworld, Burroughs works in the sighting of an underground river as a lesson in inductive reasoning.

> *"Look there!" And I pointed at the base of the cliff ahead of us, which the receding tide was gradually exposing to our view. They all looked, and all saw what I had seen -- the top of a dark opening in the rock, through which water was pouring out into the sea. "It's the subterranean channel of an inland river," I cried. "It flows through a land covered with vegetation -- and therefore a land upon which the sun shines. No subterranean caverns produce any order of plant life even remotely resembling what we have seen disgorged by this river. Beyond those cliffs lie fertile lands and fresh water -- perhaps, game!"*

Tanar of Pellucidar (1929)

> *The fall had not hurt him. It had not even stunned him and when he came to the surface he saw before him a quiet stream moving gently through an opening in the limestone wall about him. Beyond the opening was a luminous cavern and into this Tanar swam, clambering to its rocky floor the moment that he had found a low place in the bank of the stream. Looking about him he found himself in a large cavern, the walls of which shone luminously, so considerable was their content of phosphorus.*
>
> *Then slowly he made a circuit of the outer walls of the grotto, but only where the stream passed out at its far end was there any opening -- a rough archway that rose some six feet above the surface of the underground stream.*

And,

> *Where they had halted a tiny spring broke from the base of the cliff and trickled along its winding channel for a short distance to empty into a natural, circular opening in the surface of the ground. From deep in the bottom of this natural well the water falling from the rim could be heard splashing upon the surface of the water far below. It was dark down there—dark and mysterious, but the bearded ruffians gave no heed either to the beauty or the mystery of the spot.*

In Tarzan at the Earth's Core (1929), we have a flash flood.

> *The raging waters that were filling the gorge reached his knees and for an instant he was swept from his footing. Clutching at the ground above him with his hands, he lost his rifle, but as it slid into the turgid waters he clambered swiftly upward and regained momentary safety.*

Land of Terror (1944)

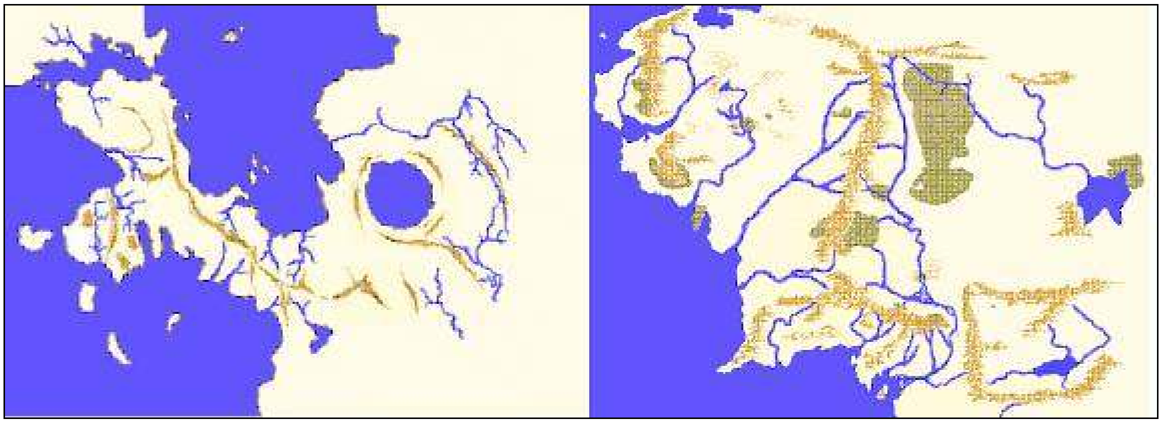
> *The cave which lay beyond the gate was of limestone formation in a hillside just outside the village. Enough light came through the outer opening to dimly illuminate the interior immediately about us. We could not immediately determine the extent of the cave; but while the walls at one side were discernible, at our left they were lost in darkness out of which trickled a little stream of clear, cold water that made its way across the floor to disappear through the outer opening.*

And,

> *These Pellucidarian rivers, especially the large ones with a sluggish current, are extremely dangerous to cross because they are peopled more often than not by hideous, carnivorous reptiles, such as have been long extinct upon the outer crust. Many of these are large enough to have easily wrecked our raft; and so we kept a close watch upon the surface of the water as we poled our crude craft toward the opposite shore.*

We'll catch Burroughs' Martian underground rivers in Chapter 89, Underground Rivers in Outer Space.

Both Burroughs and Tolkien (Chapter 16, Underground Rivers in English Fiction) strove to preserve geographical relationships from novel to novel. Below are hydrologic maps of Pellucidar and Middle Earth derived from the physiography of the respective sagas.



Of hydrologic interest is the similarity between the two imagined worlds. Both maps show enclosed basins. The circular water body in Pellucidar is the Polar Sea. Tolkien's world has two inland seas, the Rhun and the Nurnen on the lower map's right. Both sagas are set on peninsulas transected by mountain ranges, barriers to be crossed by the heroes. Both worlds are endowed by multiple rivers which, among other benefits, provide the heroes a means of transport when the plot needs to move along.

We might correctly surmise that by the time of writing, Burroughs had lived Southern California for a decade and knew about such events.

Burroughs didn't limit underground rivers to Pellucidar. Here, for example is an excerpt from The Chessmen of Mars (1922).

> *His exploration revealed not only the vast proportions of the network of runways that apparently traversed every portion of the city, but the great antiquity of the majority of them. Tons upon tons of dirt must have been removed, and for a long time he wondered where it had been deposited, until in following downward a tunnel of great size and length he sensed before him the thunderous rush of subterranean waters, and presently came to the bank of a great, underground river, tumbling onward, no doubt, the length of a world to the buried sea of Omean. Into this torrential sewer had unthinkable generations of ulsios pushed their few handsful of dirt in the excavating of their vast labyrinth.*

Fremont B. Deering

The Border Boys Across the Frontier (1911) by Fremont Deering employs the boys-plus-professor formula.

> *"Comes to my mind now," said Pete, "that it ain't exactly a well. An old Injun that used ter hang around with the Flying Z outfit tole us oncet that thar was a subterranean river flowed under here, and that once upon a time afore all the country dried up, considerable more water came to the surface here than there does now."*
>
> *"A subterranean river?" asked the professor, at once interested.*
>
> *"Yes, sir," rejoined Pete, "and not the only one in the West, either. There's one in Californy that flows underground fer purty near fifty miles, as I've heard tell."*

As the book's also cataloged as being by John Henry Goldfrap, we can only speculate on which is the pseudonym, but we can hazard a guess.

> *"This is most remarkable," said the professor. "I, too, have heard of subterranean rivers in this part of the world, but I have never had the opportunity to explore one. Did this Indian you speak of ever tell you where this river emerges?"*
>
> *"He said it come out some place across the frontier in Chihuahua; I don't jest rightly recollect where," said Pete carelessly, as if the subject did not interest him much, as indeed it did not.*
>
> *"I don't see what use a subterranean river is to anybody, anyhow," he went on. "If it was on top, now, it might be some use."*
>
> *"But this is most interesting," protested the professor, while the boys lay about with their chins propped in their hands in intent attitudes. "Then, too, if this river exists, perhaps it is even navigable."*
>
> *"Why, professor!" exclaimed Jack. "Is it not possible that it was to this river that those drawings of boats that interested and puzzled you so much had reference?"*
>
> *"Quite possible, my boy," agreed the man of science.*

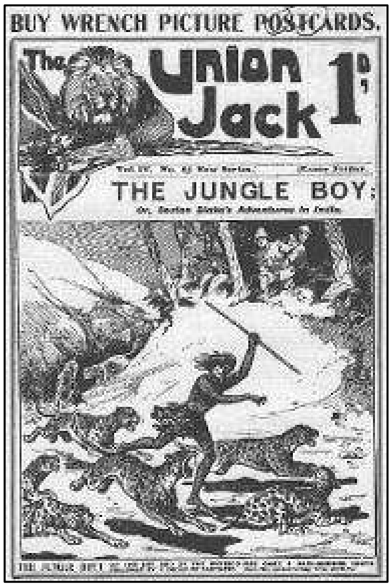
The Border Boys on the Trail (1911), The Border Boys with the Texas Rangers (1912) and The Border Boys in the Canadian Rockies (1913) give evidence of the Border Boy's territory.

Frederick Gordon

Fairview Boys on a Ranch, or Riding with the Cowboys (1917) by Frederick Gordon was the last of a series of six.

> *"It'll be dandy to go out on the ranch," mumbled Sammy, "but we surely will miss some of the fun we've had around here this summer."*
>
> *"That's so," replied Bob, a little regretfully. "I wonder if there'll be any place to swim out there."*
>
> *"There must be plenty of water somewhere around," said Frank, thoughtfully. "I've read a lot about prairie schooners, and, of course, they can't sail without water."*
>
> *"Listen to him!" shrieked Bob. "Why, you goose, don't you know that prairie schooners are only big wagons?"*
>
> *"I don't believe it," said Frank, stoutly.*
>
> *"Bob's right," declared Sammy. "I saw a picture of one a little while ago. It had four horses hitched to it and a man was driving."*
>
> *"Maybe that was another kind of schooner," suggested Frank, though weakening somewhat before the positive statements of his chums. "Anyhow, there must be ponds or lakes or rivers of some kind. How could the cattle get water if there wasn't?"*
>
> *"Maybe we'll run across some underground river that will lead to a robber's cave or something," broke in Sammy, eagerly. "You know, the kind that's running along all right and then suddenly sinks down in the ground and people think that's the end of it until they find it starting up again a good many miles away. But what's it been doing while it's been out of sight? Running through a cave of course. Robbers choose just that kind of place."*

William Murray Graydon



With the assistance of the newly-invented Dictaphone, William Murray Graydon wrote more than 100 Sexton Blake Stories and an equal number for the Sexton Blake Library, some which were subsequently used as the basis for Nick Carter stories and others rewritten for the Gordon Keith series. Graydon's pseudonyms include **Alfred Armitage**, **William Murray** and **Tom Olliver**. Adding to the bibliographic dimensionality would be his publishers' propensity to re-release stories under altered titles.

Bluntly put, Graydon sold his works over and over to Boys Clubs having short recall.

Lost Cave (1893) tells of a harrowing boat trip along an underground river, a theme which repeats in Graydon's works. The discovery of Pennsylvania's Lost River Caverns in 1883 ties into Graydon's impressionable years; he would have been 19 at the time of the discovery.

We should pause a moment for geographic clarification. There are numerous American rivers named "Lost River." In our journey, we'll encounter Lost Rivers in,

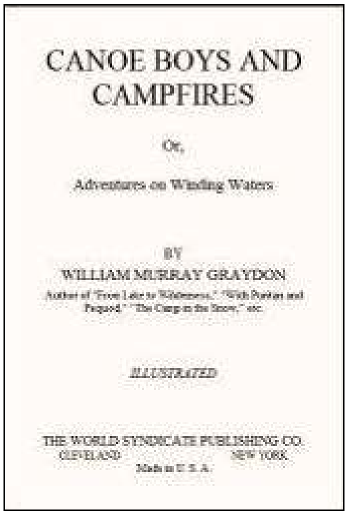
Pennsylvania	This chapter, Boys Club Serials
Indiana	Chapter 39, Karstology, Chapter 47, Wrecks of Ancient Life, and Chapter 90, Why Do We Believe What We Believe?
Kentucky	Chapter 50, Then, Madam, You Should Go and See the Great Cave in Kentucky
Wisconsin	Chapter 54, Three Tales of Two St. Pauls
Idaho	Chapter 86, the Rio San Buenaventura
New Hampshire	Chapter 83, Professor Denton's New England Underground River

Here's a taste of Graydon's Pennsylvania underground action.

> *Twenty feet below, and separated from them by a precipitous slope of rock, was a beach of shining sand a 19 dozen yards wide. It terminated in a pool of black water that was constantly heaving in turbulent eddies, and washed, on the opposite side, the steep rocky wall of the cavern.*
>
> *This subterranean stream -- for such it was -- cut directly across the corridor that the boys had been following. It issued through a gloomy hole, and where it disappeared by a similar aperture was a great mass of drift -- logs, fence rails and brush.*
>
> *This blockade formed the eddying pool, and the escaping water pouring through the interstices made the deafening roar that the boys heard.*
>
> *"There are just two courses open to us," said Roger. "We can turn back and explore the other corridor, or we can drag the boat over the drift and trust ourselves to the channel. What do you say?"*

> *The plan was fully discussed before they finally decided to trust themselves to the unknown perils of the subterranean stream.*
>
> *The angry watery snatched the boat, and away it went with a rush into the narrow and gloomy gorge, swaying from side to side and heaving and pitching with the waves.*
>
> *The subterranean channel varied in width from 10 to 15 feet. On each side was a slimy wall of rock rising a dozen feet or more to the jagged roof of the cavern.*
>
> *All at once the heaving motion ceased and the angry roar of the waves seemed to fade away in the distance. A terrible thought occurred to Roger. Was this the end of the subterranean stream? Was its outlet from this point beneath the surface? The fact that the boat was apparently motionless seemed to indicate as much.*
>
> *"We are shut in here forever," cried Clem despairingly. "I knew how it would be. What fools we were to meddle with this stream."*
>
> *"That's so," echoed Gid, "and we can't go back the way we came, either."*

Canoe Boys and Campfires or Adventures on Winding Waters (1907) was another Graydon tale of subterranean discovery.



CANOE BOYS AND
CAMPFIRES

Or,

Adventures on Winding Waters

BY
WILLIAM MURRAY GRAYDON
Author of "From Lake to Wilderness," "With Puritan and
Pequod," "The Camp in the Snow," etc.

ILLUSTRATED

THE WORLD SYNDICATE PUBLISHING CO.
CLEVELAND NEW YORK
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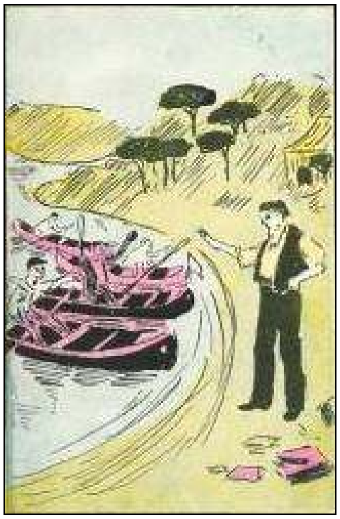


A few paragraphs follow. Note Ned's reference to limestone hills. As for the "two outlets," however, he's just making the story work out.

> *A few yards down stream the wall of rock jutted out slightly and then receded. As the canoes rounded this a great heaving wave -- the vanguard of the flood -- tossed them high on its crest and cast them, like a stone from a catapult, straight toward a black, semi-circular hole in the base of the cliff. A furious current swept in the same direction, and even had the boys realized the nature of this new peril they could have done nothing to help themselves.*
>
> *The canoe pitched and tossed dizzily, and by the cold air that surged on his face, and the spray that spattered him, Ned knew that he was moving at rapid speed. Suddenly a cry rang in his ears*
>
> *He understood at once what had happened. The underground stream made a sharp curve at this point, and the force of the current had thrown the canoes far out on a sandy beach. From above, the yellow flood came roaring and tossing through a passage some twenty feet wide, and nearly the same in height. Below the angle it plunged on under the same conditions.*
>
> *The beach was about ten yards long, and sloped back half that distance to a slimy wall of rock. On the opposite side of the stream the wall fell sheer into the water, and overhead was a jagged roof that glittered and sparkled in the rays of the lantern.*

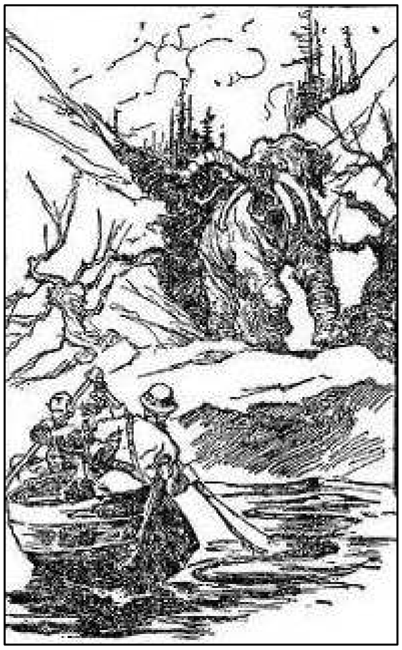
> *"And what happened to us, Ned? Didn't the current drag us into a hole in the cliff?"*
>
> *"Yes," said Ned, "that's it exactly, and we are now in an underground cavern. Don't be alarmed," he added quickly, noting the sudden pallor on his companion's face, "our situation is not so terrible after all. Caverns of this sort are always found among limestone hills, and they usually have two outlets. This one is no exception to the rule, and I'll tell you why I think so. In the first place you must remember that the creek was nearly four feet high before that dam broke. The extra volume of water is what makes this terrific current through the cavern and the very fact that the water goes on through without damming up proves to me that it has an outlet."*
>
> *Without a ray of light to guide them it would be a difficult matter to find the main channel of the stream again, and follow it to the outlet which must certainly exist. There was danger of falling into deep holes, of striking sharp rocks, or blundering into other side passages with which the cavern was doubtless honeycombed.*

The Graydon bibliographer might recognize the above publication as On Winding Waters, A Tale of Adventure and Peril (1902), or perhaps as On Winding Waters or The Cruise of the Jolly Rovers, published ten years before that. A rousing story is worth a few titles.

In Graydon's The Wonderful Adventure on the Yukon Tributary (1898), Quin traverses an underground river to a valley of gold.

> *Quin fell asleep with his head pillowed on a roll of blankets. An hour later, waking with a start, he was alarmed and bewildered to find himself in absolute darkness; he heard the swift rush of water, and felt the cool, damp air.*
>
> *"Where am I?" he cried.*
>
> *Don't be scared, man," Cranes voice answered. "It's all right. We're floating underground for a bit, but it won't be long until we get into sunlight again."*
>
> *Awed by their mystic surroundings, the voyagers were silent for a time. Suddenly a gray glimmer of light was seen in the distance. It rapidly grew larger and nearer, expanding to a spacious archway. Then it seemed to hurl itself forward, and the tossing craft was shot out into the dazzling glare of day.*
>
> *"Look!" shouted Crane. "The valley of gold!"*

But as shown to the right, there's more than precious metals at the headwaters!



On an excursion to Algeria -- our hero is quite the traveler -- Quin takes the opposite route, and underground river ride to escape peril. From A Treacherous Rival (1900),

> *Before they could realize their peril they were sucked into a cavernous hole, and dragged on at a dizzy speed through the fearful darkness.*
>
> *A rounded boulder just beneath the surface forced them apart. A foaming wave submerged Quin, and as he rose he heard a wild, desperate cry. Then, as he struck out with his arms and legs, he grasped a pinnacle or rock and clung to it for a short time, while he gained breath and strength.*
>
> *When he could hold fast no longer he trusted himself to the stream, and after several minutes he floated out from beneath the great mountain, into fresh air and sunshine. He swam clear of the dangerous reefs, and at length, little the worse for the struggle, he was thrown ashore by a circling eddy of smooth water.*

In Wildest Africa, a Magnificent Complete Story, Introducing Ex-President Roosevelt and Matthew Quin, Wild Beast Agent, Boys' Friend Library No. 120 (1910) brought on board every Boys Club favorite politician, but Teddy wasn't with the boys when they crept under the Solomon's fortress.

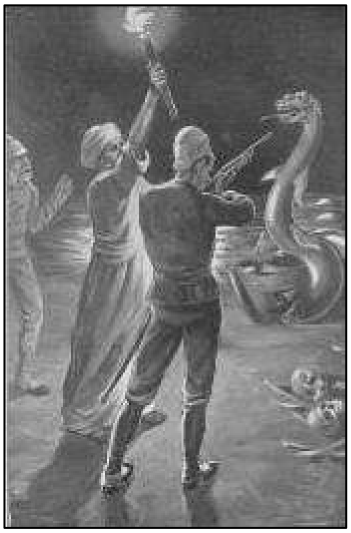
> *They were under the foundations of the ancient fortress, and they were also considerably below the level of the enclosure. They did not know that, however, else they would have felt less confident of gaining their freedom as they stood peering about them.*
>
> *It was a place to arouse superstitious terror and make the flesh creep. The flickering glare of the osier torches revealed on all sides natural walls of granite, and showed overhead a low ceiling studded with stalactites. The cavern ended close to the right, where there was a bubbling spring of water, fringed by a strip of hard sand, on which lay a long double-edged sword and several earthen vessels. To the left flowed the stream, vanishing in a winding tunnel that was less than half a dozen yards in width.*

As with Graydon's other African adventures, this one is typical of the era's prevailing attitude toward Blacks, as well as having appallingly high death counts of both animals and humans.

The River of Darkness, or Under Africa (1890) was Graydon's tour de force of colonialism, a tale of British adventures in the Dark Continent. It was doubly dark, actually, because the heroes escaped black savages via an underground river. Graydon's position on racial matters was more nuanced, however, than it might seem in modern light. In pre-Civil War Pennsylvania, the Graydon family was adamant abolitionist. The author, however, who lived much of his adult life in Britain, also subscribed to the Victorian concept of noble colonialism. The natives in Graydon's fiction are thus in need of Anglo tutelage, the wise subjects being willing disciples, the foolish ones, inexcusably resistant.

> *Melton and Canaris were close behind, and together they went up into the vast expanse of the cavern. Under foot was hard, compact sand, and in a moment more the glare of the lamp was reflected on running water, and they stood on the brink of the mysterious underground river.*
>
> *It was impossible to judge of the width of the stream. It might be very narrow and it might be very broad. The flowing water made not a sound, and yet the current was swift, for a bit of paper that Melton tossed in was snatched from sight immediately.*
>
> *"If this current continues all the way," observed Forbes, "eight hundred miles will be nothing at all."*

This, of course, was before they meet the sea serpent.



> *"I don't admire the appearance of that river very much," remarked the colonel. "It comes through the cliff as though shot by a cannon. No wonder, though, when you think of the terrible pressure from above."*
>
> *"We will make up for lost time by rapid traveling, then," said Forbes.*
>
> *"Ah, you think so?" cried Sir Arthur. "Bless me, I hope we will. I have an engagement to dine with Lord Balsover at the Hotel Bombay at Aden on the 10th at six o'clock in the evening. He touches there on his way to India, and I can't disappoint him, you know."*

As River of Darkness is too good a title to be so squandered, James Grady employed it in 1991 and Rennie Airth, in 1999. Both titles are metaphoric, a topic of Chapter 29. Grady's tales is about a has-been CIA agent. Airth's work is about a has-been Scotland Yard detective. As "Grady" is suspiciously close to "Graydon," maybe the latter is still writing.

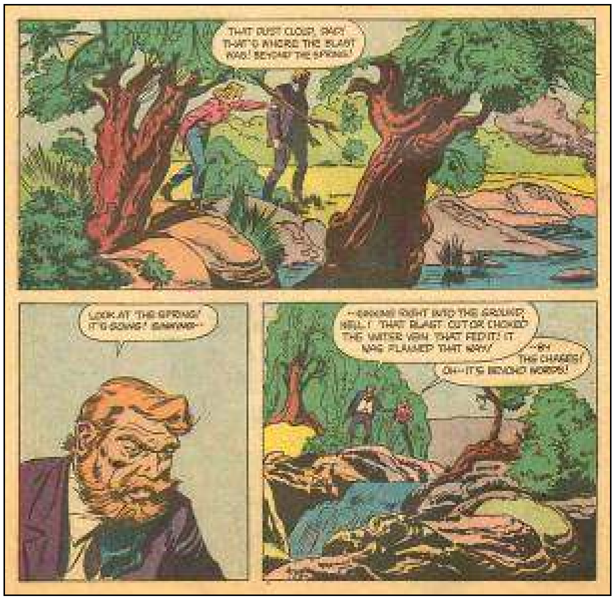
Zane Grey

Some may uphold Zane Grey as a literary artesian, but others would argue that his works are Boys Club fodder, just for older boys. Both Gray and Louis L'Amour churned out roughly 100 volumes, generally of the cowboy genre, but as L'Amour came no closer to underground rivers than Callaghen (1972), advertized to be about following an "underground river of gold," clearly metaphorical, we'll not count Louis.

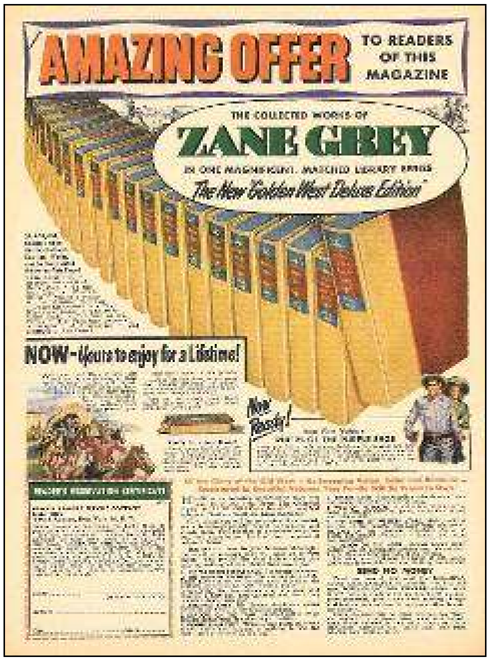
Gray, on the other hand, employed a physical underground river in Desert Gold (1913).

> *The time was near the end of the dry season. Perhaps an underground stream flowed from the range behind down to the valley floor, and at this point came near to the surface. Cameron had heard of such desert miracles.*
>
> *He was just in time to see the last of the water. It seemed to sink as in quicksand. The shape of the hole had changed. The tremendous force of the blast in the adjoining field had obstructed or diverted the underground stream of water.*
>
> *Suddenly he again heard the dull roar of falling water. It seemed to have cleared itself of muffled vibrations. Yaqui mounted a little ridge and halted. The next instant Gale stood above a bottomless cleft into which a white stream leaped. His astounded gaze swept backward along this narrow swift stream to its end in a dark, round, boiling pool. It was a huge spring, a bubbling well, the outcropping of an underground river coming down from the vast plateau above.*

Following are the pertinent panels from Desert Gold's comic book version. We could have thus saved Gray for Chapter 24, Underground Rivers in the Comics, but that would truly infuriate Gray devotees. In deference to Gray's hard-cover credentials, we include an advertisement for his complete works.


THAT DUST CLOUD, PAP! THAT'S WHERE THE BLAST WAS! BEYOND THE SPRING!
LOOK AT THE SPRING! IT'S GOING! SINKING--
--SINKING RIGHT INTO THE GROUND! WELL! THAT BLAST CUT OR CHOKED THE WATER VEIN THAT FED IT! IT WAS PLANNED THAT WAY!
--BY THE CHASES! OH--IT'S BEYOND WORDS!

"Desert Gold"
Zane Grey Comics # 467
May-June 1953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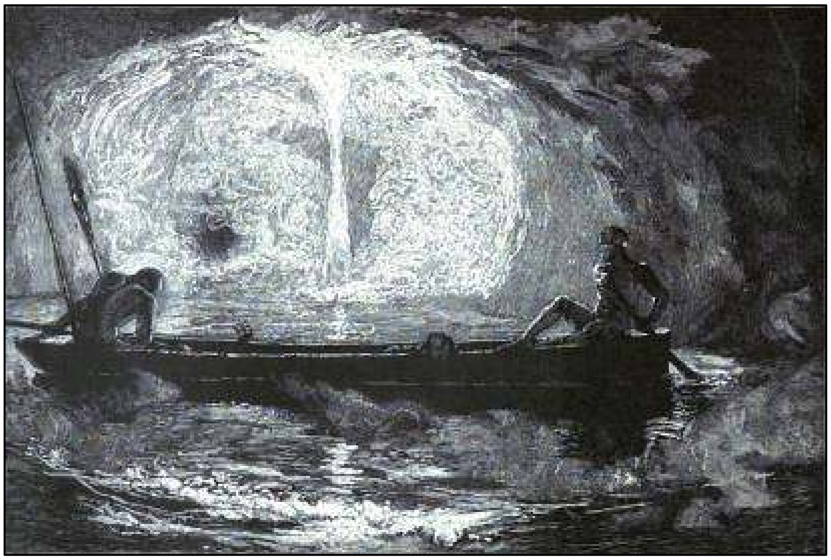
SEND NO MONEY

1951 Zane Grey Book Offer

H. Rider Haggard



Haggard's sequel to King Solomon's Mines (1885), Allan Quatermain, Further Adventures and Discoveries (1887) tells of a white race in Africa, a cross between Zoroastrian Persians and Druidic Celts. The travelers reach this country through an underground river which conducts them past a jet of flame and into to the country of living sacrifices.

> *By the river's edge was a little shore formed of round fragments of rock washed into this shape by the constant action of water, and giving the place the appearance of being strewn with thousands of fossil cannon balls. Evidently when the water of the underground river is high there is no beach at all, or very little.*
>
> *Our river that was, Sir Henry said, a literal realization of the wild vision of the poet.*

Haggard's endnote, "Where Alph the sacred river ran through caverns measureless to man down to a sunless sea," identifies the poet as Samuel Coleridge. As for the "sunless sea," we will further visit its shores in Chapter 30, Down to a Sunless Sea.

Indeed Haggard's plots are violent and racist and his language, stilted, but he doesn't take his readership as uncultured. His Stygian line,

> *And when all's said and done an underground river will make a very appropriate burying-place.'*

In the "Authorities," Haggard mentions,

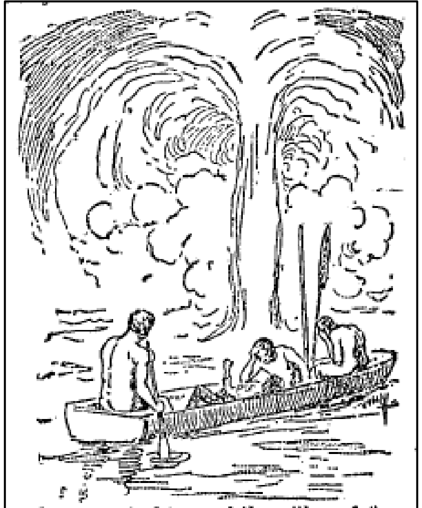
> *There is an underground river in "Peter Wilkins," but at the time of writing the foregoing pages I had not read that quaint but entertaining work.*

Which leads us to the underground river of **Robert Paltock**'s Life and Adventures of Peter Wilkins (1751), a tale of an English castaway and a remote race of humans, a Gulliver's Travels meets Robinson Crusoe.

> *I soon found myself in an eddy; and the boat drawing forward beyond all my power to resist it, I was quickly sucked under a low arch, where, if I had not fallen flat in my boat, having barely light enough to see my danger, I had undoubtedly been crushed to pieces or driven overboard. At length, finding the perturbation of the water abate, and as if by degrees I came into a smoother stream, I took courage just to lift up my affrighted head; but guess, if you can, the horror which seized me, on finding myself in the blackest of darkness, unable to perceive the smallest glimmer of light.*
>
> *However, as my boat seemed to glide easily, I roused myself and struck a light; but if I had my terrors before, what must I have now! I was quite stupefied at the tremendous view of an immense arch over my head, to which I could see no bounds; the stream itself, as I judged, was about thirty yards broad, but in some places wider, in some narrower. It was well for me I happened to have a tinder-box, or, though I had escaped hitherto, I must have at lust perished; for in the narrower parts of the stream, where it ran swiftest, there were frequently such crags stood out from the rock, by reason of the turnings and windings, and such sets of the current*

> *against them, as, could I not have seen to manage my boat, which I took great care to keep in the middle of the stream, must have thrown me on them, to my inevitable destruction.*

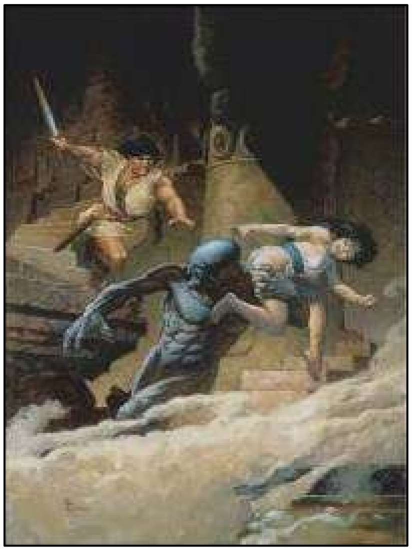
The Quatermain saga was serialized in numerous newspapers, an illustration from the Alton [Iowa] Democrat, March 24, 1888, shown to the right.


On we rushed toward the pillar of fire.

Robert E. Howard

Robert Howard lived a life perhaps as tortured as that of Poe, Howard's end being self-inflicted by a .380 Colt automatic, not drugs and alcohol, however. Poe was 40. Howard was but 30. Much of Howard's output was serialized in Weird Tales.

We could save Howard's contributions for Chapter 24, Underground Rivers in the Comics, but his impact in that venue was a result of his pulp fiction, his most lasting character being Conan the Barbarian, pictured to the right saving a lass from the bubbling stream of slime.



For a sample of Howard's underground river prose, three tales suffice.

The Lost Race (1927),

> *The cave debouched into a cavern so vast as to be almost incredible. The mighty walls swept up into a great arched roof that vanished in the darkness. A level floor lay between, and through it flowed a river; an underground river. From under one wall it flowed to vanish silently under the other. An arched stone bridge, seemingly of natural make, spanned the current.*
>
> *All around the walls of the great cavern, which was roughly circular, were smaller caves, and before each glowed a fire. Higher up were other caves, regularly arranged, tier on tier. Surely human men could not have built such a city.*

The Treasure of Tartary (1933),

> *I have but to pull that, and the treasure falls into the subterranean river which runs below this palace, to be lost forever to the sight of men.*

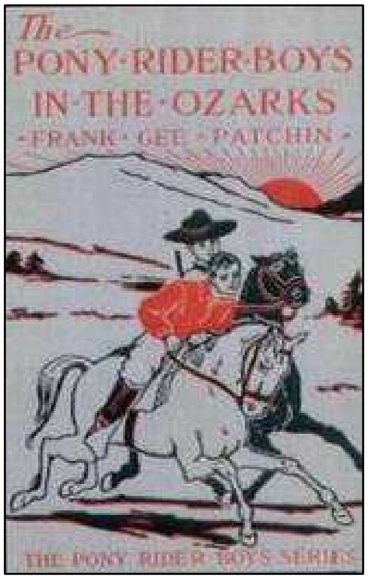
Jewels of Gwahlur (1935), a Conan tale,

> *I've always known there was a subterranean river flowing away from the lake where the people of the Puntish highlands throw their dead. That river runs under this palace. They have ladders hung over the water where they can hang and fish for the corpses that come floating through.*

Not a pleasant scene, but Boys Clubs can handle it.

Frank Gee Patchin'

We've Frank Gee Patchin's 12-volume Pony Rider Boys series. In The Pony Rider Boys in the Ozarks, or The Secret of Ruby Mountain (1924), the lads ride not their ponies, but a rail car, into a mine.



> *"Not necessary," said Mr. Phipps. "It is seldom that anyone has occasion to go through this tunnel -- practically never unless something happens to a car in here. There are lights along that may be turned on if necessary, but it would be a needless expense to keep them going all the time."*
>
> *"What's that loud noise?" asked Tad.*
>
> *His ears had caught a booming roar that was a new note in the terrifying sounds of the underworld through which they were traveling.*
>
> *The boys started uneasily.*
>
> *"It's water," shouted the guide. "A cataract in an underground water course. These courses have cut channels all through the limestone rocks in the Ozark Uplift."*
>
> *This somewhat calmed the nerves of the lads, though not wholly so. Faster and faster rolled the car and louder and louder grew the roar of the cataract.*

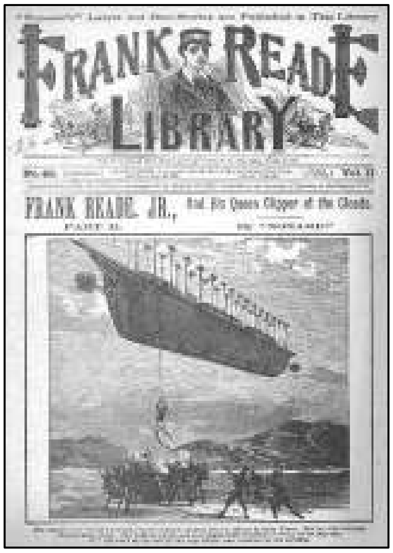
What, we wonder, awaits the Pony Rider Boys within Ruby Mountain?

Luis Senarens

Jack Wright was the Edisonade hero of the 121-volume Victorian dime novel series written by Luis Senarens, the "American Jules Verne." A few Jack Wright stories were also credited to **Francis W. Doughty**.

Senarens also popularized the Frank Reade dime novel series, having taken the reins from Harry Enton, the pseudonym of Harold Cohen. Who wrote what gets a bit confusing.

Senarens took Reade's exploits to Antarctica, Australia, Central America, Central Asia, the jungles of Africa, inside the hollow earth and even the edge of space. Reade inventions included electric locomotives, one-person battery-powered electric flying suits, "electric cannons" (pneumatic machine guns), an instant camera, motorcycle-like bicycle cars, armed and armored all-terrain omnibuses, chariot-like "electric phaetons" and yachts that could travel underwater.


FRANK READE LIBRARY
FRANK READE, JR., And His Queen Clipper of the Clouds

Jules Verne's influence in apparent in Senarens' titles, the ones about underground waters listed below.

Frank Reade, Jr., Exploring an Underground River with his Submarine Boat (1892)
Six Weeks in the Great Whirlpool (1893)
100 Miles Below the Surface of the Sea (1894)
Lost in the Great Undertow (1894)
The Underground Sea (1894)
Over the South Pole (1895)
1,000 Fathoms Deep (1895)
7,000 Miles Underground (1895)
50,000 Leagues Under the Sea (1895)
The Black Whirlpool (1895)
Lost in the Polar Circle (1896)
For Six Weeks Buried in a Deep Sea Cave (1894)
Wrecked at the Pole, or Jack Wright's Daring Adventures in the Frozen Sea (1896)

Reade slaughters Indians and Africans by the thousands and loots whatever's not nailed down. Irish, Afro-American, Jews and Mexicans are all met with ridicule. Senarens was a low point of American popular fiction.

Alpheus Hyatt Verrill

Verrill enjoyed callings other than pulp fiction, one as natural history editor of Webster's International Dictionary, another as inventor of the autochrome process of natural-color photography. Of Verrill's more than 100 fictional works, we've the four-volume Boy Adventurers series, and with a given name as Arcadian as "Alpheus," the author of course had his Boy Adventurers discover underground rivers.

In The Boy Adventurers in the Land of the Monkey Men (1923), Fred, Harry, and Dr. Woodward, visiting British Guiana in search of a radium deposit, are taken captive by bush negroes. On escaping they find themselves in a valley inhabited by black-skinned, flat-footed, broad-faced, mop-haired giants. The king of the giants, however, is treacherous, and it is only by luck that the explorers survive his schemes. Woodward teaches the savages how to make rude stone tools and weapons. Making their escape through an underground river, they continue on their search for radium.

Verrill, we come to discover, wasn't only a writer of fiction. In Rivers and Their Mysteries (1922), Verrill takes on the role of educator.

> *In many parts of the world where limestone is the country rock we find rivers and streams issuing from apparently solid hills, flowing for long distances and then suddenly disappearing as though swallowed up by the earth. In such localities, too, rivers will at times appear where no river has been before and after flowing for a variable length of time they will all at once dry up and disappear. But there is nothing mysterious about this for such rivers do not really flow from nowhere nor do they cease, but are merely underground rivers which flow above ground for a portion of their course or which, swollen by floods or other causes, find an outlet from their underground channels and flow across the land until the excess water has been drained off and they again resume their original course.*
>
> *If it is merely a flood which has caused it to overflow its underground banks, the new stream will dwindle away and disappear as soon as the surplus water has been drained off and the subterranean river falls to its ordinary size. In many places streams of this character appear regularly every spring, for mysterious and strange as they may seem they are in reality no more remarkable or abnormal than the temporary waterways which are formed by ordinary rivers when the water overflows the banks during freshets. In some places all of the streams are underground, while in other districts there are both subterranean and surface rivers, for one stream may find a fissure through which to drop and form an underground river while another may not, or again, a river may be so large that the greater portion of its water remains above ground although much of it flows through underground channels.*

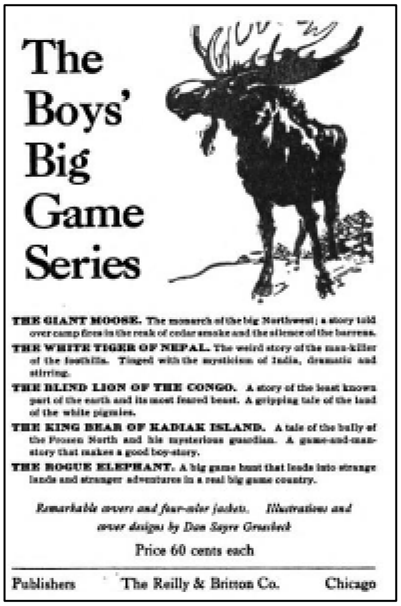
According to Theodore Roosevelt, "It was my friend Verrill here, who really put the West Indies on the map." Perhaps this is why so many Americans are ill-informed about these lands.

It's difficult to reconcile the author's geological proficiency with his fictional creations, but it may be a case of knowing what sells the most books.

Elliot Whitney

Boys Clubs loved hunting, even if they didn't actually do it. From The Rogue Elephant (1913) by Whitney,

> *This lake, it seems, is fed by underground springs -- hot springs, that spout up and fall like fountains on the water; its outlet is also by an underground river, so that the lake lies, sweltering in the sun and surrounded by desert and jungle and marsh, where no people live.*



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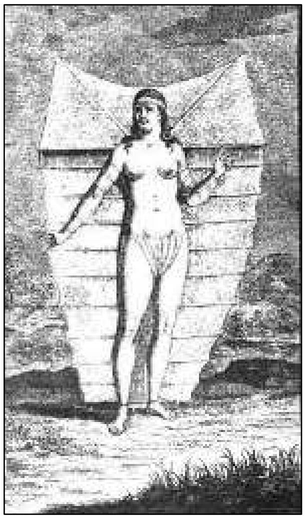
CHAPTER 21

BOYS CLUB SINGLES

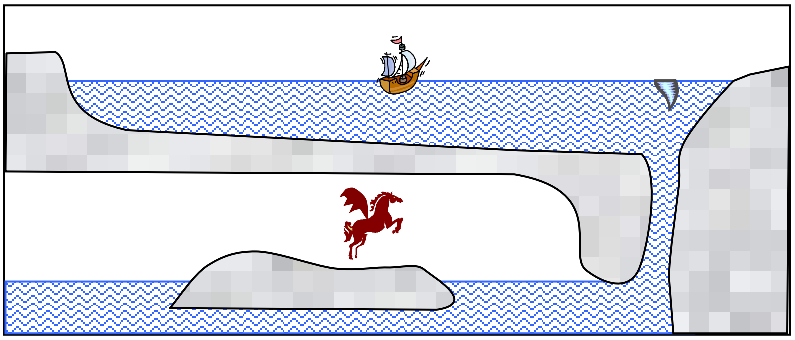
In this chapter we'll meet Boys Club authors who didn't capitalize on serialization. In most cases, we'll introduce them chronologically.



In **Robert Paltock**'s The Life and Adventures of Peter Wilkins (1751), young Peter manages to steal a ship together with other English waifs and strays, but unfortunately, none of them can navigate it, and they eventually get lost. Eventually, he begins to explore in a ship's boat, and is swept by a current into a vast underground cavern. He sets up house on a small island in Robinson Crusoe style, investigating and adapting the local flora and fauna. He keeps hearing voices, which he stoutly dismisses as those of birds, until one day he finds a beautiful girl unconscious outside his hut.

> *Says I, "Quilly, how your cooks dress their victuals. I have eaten many things boiled, and otherwise dressed hot, but have seen no rivers, or water, since I came into this country, except for drinking, or washing my hands, and I don't know where that comes from. And another thing," says I, "surprises me, though I see no sun as we have."*

We can see why a Boys Club would like this wolume in their library.



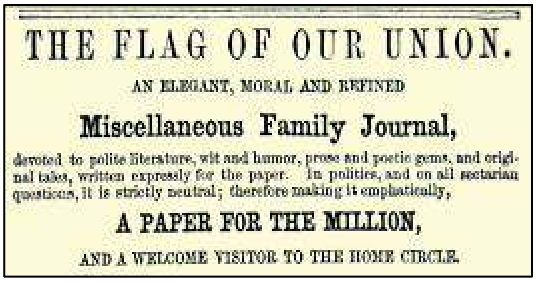
In Icosameron (1788) by **Giacomo Casanova**, shipwrecked siblings are dragged by currents to an underwater crevice and then through froth until they emerge on an island floating at the earth's center. The fauna of is similar to that of Europe except for the flying horses.

Robert E. Landor, The Fountain of Arethusa (1848) contains an account of a journey through a physical world in the center of the earth illuminated by its own sun. We won't belabor the likely influence of John Cleves Symmes.

> *A few minutes only were sufficient to exchange all this splendour for such solitude as pleased me even better. By an easy flexure, the river ran half round some elevated land covered with the shadiest trees, and then lost its way among an infinity of small verdant islands. Even they who were long familiar with this labyrinth, could hardly have determined what was the water's breadth, or where its shore! Leaving the midstream, we floated over pools and shallows which appeared, in some parts, to have been paved with chrysolites and amethysts, in other parts, to have been filled with flowers like our parterres.*

As for the real Fountain of Arethusa, we must wait until Chapter 28, Et In Arcadia Ego.

The title, "Waldon, the Half-Breed" by **William H. Bushnell**, Flag of Our Union, October 21, 1865, wouldn't pass muster by today's cultural standards, but as adventure, it lacked little.



THE FLAG OF OUR UNION.

AN ELEGANT, MORAL AND REFINED

Miscellaneous Family Journal,

devoted to polite literature, wit and humor, prose and poetic gems, and original tales, written expressly for the paper. In politics, and on all sectarian questions, it is strictly neutral; therefore making it emphatically,

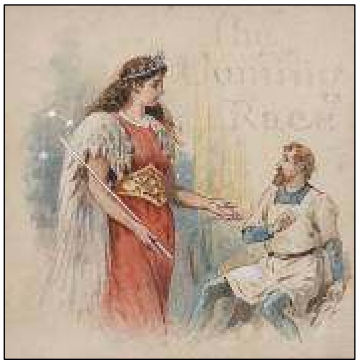
A PAPER FOR THE MILLION,

AND A WELCOME VISITOR TO THE HOME CIRCLE.

> *Suddenly his feet slipped from under him, and his hand aching with the recent terrible struggle, alone rested on the slimy, mossy rock. To retain his hold was impossible. Slowly but surely he slipped down, down, but whither he dared not think. In a moment he was clutching at the intangible air alone, and with a cry of despair ringing from his lips, he fell into a yawning pit, a dark subterranean stream.*

The Flag had seen better days, publishing Edward Alan Poe seven times in 1849.

Edward Bulwer-Lytton, The Coming Race (1871) tells in turgid prose of an American's descent into a deep mine, at the bottom of which is a broad road lit by gas lamps. The road leads into an underworld of "lakes and rivulets which seemed to have been curved into artificial banks; some of pure water, others that shone like pools of naphtha." Unfortunately, Lytton's underworld also contains descendents from the deluge who plan to emerge and conquer the surface world.



George Owen's The Leech Club, or Mysteries of the Catskills (1874) draws upon the readers' knowledge of Greek lore.

> *Finally they reached a narrow defile bounded on each side by a precipice. From this defile flowed a stream of water, beside which there was barely room to enter. This they knew from the description given by the old mountaineer, was the ravine they were seeking. Climbing from boulder to boulder, wet with the spray of the brawling stream, they make their way into the defile.*
>
> *"Ah! Horace! Verily we have entered the infernal regions. I felt, when we were passing through the defile, climbing, slipping, and sometimes wading through the steam, that we were really crossing the river Styx, and I thought of calling the ferryman Charon to our aid."*
>
> *"Indeed," said Horace, "if we don't meet that Stygian boatman or some of his crew here, we need not seek them elsewhere, but may be content till they come for us of their own accord."*

In "Davy Crockett on the Track, or The Cave of the Counterfeiters," by **Frank Carroll**, Saturday Evening Post, January 31, 1874, young Ken Gordon is captured by the counterfeiters.

> *A sensation of fear ran through the mind of the interloper on finding himself discovered, and by this dangerous man. The good-natured, mocking tone of the other was of little assurance, for he knew him to be odd and cruel, a man of that temperament that can commit murder with a smile on his face and a jest on the tongue*

> *Gordon, however, was too well aware of the company he was in, and had too much command over his feelings, to permit and sense of fear to display itself. He was in the lions den and must face the danger with a lion's boldness.*

As literature should be instructive, however, the adventure is interspersed with informative passages.

> *The many caverns of the west, among them the giant of underground excavations, the great Mammoth Cave, are supposed to have been formed by the action of water.*
>
> *Subterranean streams and rivers now run through them, following, probably, natural crevices in the rock, along whose course they have dissolved and fretted away the softer portions of the stone, excavating, in one place immense halls, in others, where the rock has proved harder, narrow apertures.*

Boys Club members enjoyed knowing such things.

"Among Bushwhackers," an unattributed feature in the May 30, 1881, Aberdeen Daily News employs Poe-like imagery.

> *Then I was slowly lowered down, down, down, through the blackness. So slow was my descent that I seemed to be suspended for hours and to sink miles into the heart of the earth. The pain of the slender cord cutting into my flesh was well nigh intolerable, and I bear the evidence of this today; with each moment the moaning, gurgling and groaning from the unknown depths into which I was sinking, became more distinct and horrible.*
>
> *Suddenly, those above let go of the rope, and with a yell of despair I dropped, I do not know how far, into the water that closed above my head. As I rose to the surface choking and gasping for breath, I felt I was being swept forward by a powerful current, and as I again sank my feet touched the bottom. A moment later I stood in water up to my shoulders and again breathed freely. For some time I was confused beyond the power of thought by the hollow roar of the black waters rushing through those awful caverns. All surrounding space seemed filled with snarling, formless monsters cautiously advancing and making ready to spring at me. Even now I often awake at night with the horror of that moment strong upon me. It was so unendurable that I resolved to end it. It was with great difficulty that I maintained my footing. I could not do so much longer. Why should I attempt to? There was absolutely no hope of escape. I tried to pray, "Oh, Jesus, receive my soul." Then my muscles relaxed, and I was swept away by the rushing torrent.*

At the other end of the writing spectrum, an excerpt from The Four Canadian Highwaymen, or The Robbers of Markham Swamp (1886) by **Joseph Edmund Collins** reminds us of the rule: An author may quote conversations phonetically, but should otherwise employ standard spelling.

> *The clay into which the roots of the trees had fastened themselves was quite solid, and was held fast in the thick tangle of roots. So for many years you could hear the river floween*

> *beneath the ground with a subdued gurgleen sound. Hunters avoided the wood, for some careless persons had come here and fallen through the holes into the rusheen tide. Their bodies were afterwards found floateen in Silent Lake. One day my grandfather and two of his men came to see the treacherous underground river; and they moved cautiously down the stream till they came where it sank into a hole in the ground, that looked like a huge sluice-way.*
>
> *My grandfather looked at the strange sight for a time, and then at the great bridge of trees and boulders that lay across the original course of the river. They wondered why he gazed at all so earnestly; and why his eyes grew so bright. Then he slapped the capteen, who was yet a boy, upon the back, and said,*
>
> *"Just the very place we want. Here we will have a quiet castle of our own, where no limb of the law can find us."'*

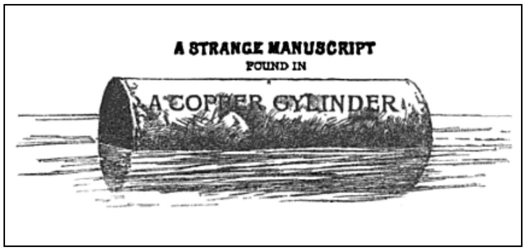
It is not uncommon for Boys Club, we observe, to suspend the rules of spelling.

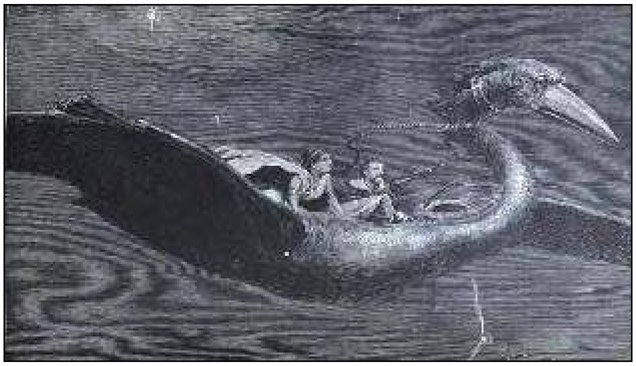
In the World Below (1897) by **Fred Thorpe** features a Subterranean Boring Car, its outer shell fitted with revolving cutting edges, its inner core, cabin and stationary. In a planned bore from the Amazon to China, the machine runs out of control and the passengers find themselves swimming in the water of an inner earth. The vegetation is odd and the force of gravity is weak. The explorers are about to be speared by blue-skinned natives when they are rescued by a white man who'd fallen into the inner world from the Andes. The Subterranean Boring Car is their only chance for escape, but it's submerged and blocking the drainage of the inner world. As the waters rise, the explorers wisely build a raft. The fortuitous appearance of a white savior isn't an uncommon happening in such novels. In the World Below was written within memory of Henry Stanley's, "Doctor Livingstone, I presume?"

In **Charles W. Beale**'s The Secret of the Earth (1899), Guthrie and Torrence Attlebridge, co-inventors of the airplane, enter the earth's interior where they find roofless houses and a city of white and gold, a paradise that was man's first home. As the Wright Brother's success at Kitty Hawk wasn't until 1904, the Attlebridges would seem to deserve aeronautical recognition. As they were acting as agents of an innerterrestrial benefactor, however, we tend to minimize their accomplishment.

James De Mille's A Strange Manuscript Found in a Copper Cylinder (1888) is couched in the style (if not plot plagiarism) of Poe's Arthur Gordon Pym. Adam, the hero, is swept into a channel that leads into a chasm into the depths of the earth.

> *The darkness grew so intolerable that I longed for something to dispel it, if only for a moment. I struck a match. The air was still, and the flame flashed out, lighting up the boat and showing the black water around me. This made me eager to see more. I loaded both barrels of the rifle, keeping my pistol for another purpose, and then fired one of them. There was a tremendous report, that rang in my ears like a hundred thunder-volleys, and rolled and reverberated far along, and died away in endless echoes. The flash lighted up the scene for an instant, and for an instant only; like the sudden lightning, it revealed all around. I saw a wide expanse of water, black as ink -- a Stygian pool; but no rocks were visible, and it seemed as though I had been carried into a subterranean sea.*

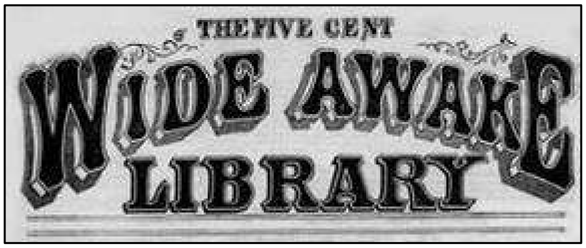




Mamelons & Ungava, A Legend of the Saguenay (1890) by **W.H.H. Murray** tells of subterranean Atlantilian army of the dead.

> *So the two boats went through the lovely lakes, floating slowly down the flowing rivers without hap or hazard, until they came to the last portage, whose gloomy tide flows out of death and into bright life at Mamelons.*

We like "The Skeleton Island, or A Cruise in an Underground River" by **Roger Starbuck** in The Five Cent Wide Awake Library, Issue 1054 (1891), not as much for the story, as for the magazine name.



From its name, Golden Days for Boys and Girls wasn't exclusively for Boys Clubs, though our example has that ring.

GOLDEN DAYS
FOR BOYS AND GIRLS

From "The Mutiny on Board of the Sea Eagle, or the Adventures of a Homeless Boy" by **Ralph Hamilton**, November 12, 1892,

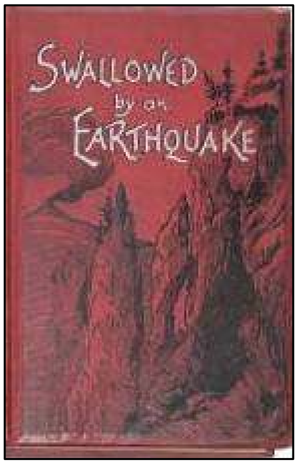
> *The entrance to this odd underground water-way was not more than four feet in height by six wide, but he unhesitatingly entered the narrow channel, bent upon seeing what there was of it and where it led to.*
>
> *Drawing a long breath of surprise and satisfaction, he ceased rowing, and, as the boat came to a stand-still on the glassy surface of this subterranean sea, he uttered an exclamation of wonder, and looked around him in a maze of doubt and admiration.*

In **Ingersoll Lockwood**'s satirical Trump's Marvelous Underground Journey (1893), an opening in the earth conveys Trump into the interior where he meets the Transparent Folk and the Rattlebrains.

Note the ease of fishing on the glassy river.

> *From now on Lord Bulger and I made ourselves perfectly at home among the Mikkamenkies. One of the royal barges was placed at our disposal, and when we grew tired of walking about and gazing at the wonders of this beautiful city of the under world, we stepped aboard our barge and were rowed hither and thither on the glassy river; and if I had not seen it myself I never would have believed that any kind of shellfish could ever be taught to be so obliging as to swim to the surface and offer one of their huge claws for our dinner, politely dropping it in our hand the moment we had laid hold of it.*

Baron Trump's
Marvellous Underground
Journey
By
Ingersoll Lockwood



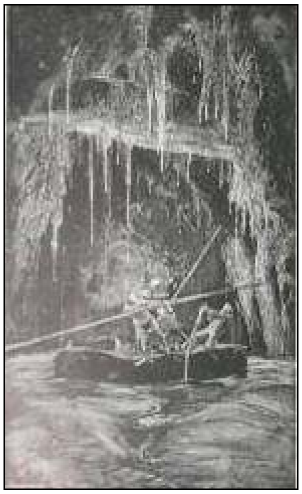
Swallowed by an Earthquake (1894) by **E. Douglas Fawcett** was marketed as a "New Story of Romance and Adventure for Boys." From the book,

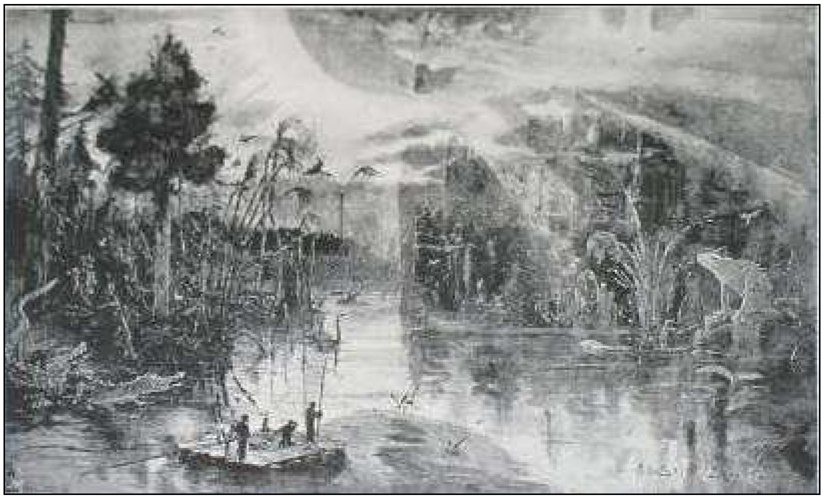
> *Never before had a voyage such as ours been ventured. Three hundred feet below the valley of the Scherno we were threading a subterranean watercourse that led no one knew where.*

The review in the Journal of Education 16, 1894, notes the centrality of the underground river setting.

> *Various writers have made use of underground passages and subterranean rivers for extricating their heroes and heroines from apparently hopeless positions, but Mr. Fawcett introduces us to an underground world, lighted by an aurora borealis, still peopled by the sauria of the mesozoic time, and also by savages of the stone age, who converse chiefly in clicks, and worship the fire-god... It is a pity that a false note is so often struck by the two young men of the party. Naturally, they could not help being much more modern than their entourage, but they need not have been slangy. A more serious, or even tragic, demeanor would have harmonized better with the story... It is not an easy book to illustrate, but two of the pictures -- the underground river, and the lake of the Aurora -- have come out very well.*

Below are the mentioned illustrations.





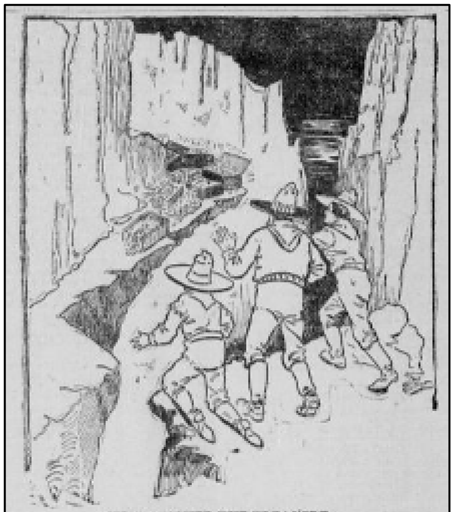
The Marble City Being the Strange Adventures of Three Boys (1895) was **R.D. Chetwode**'s warning to Boys Clubs regarding the horrors of socialism. Bob, Jack and Harry -- Boys Club heroes prefer such unencumbered names -- set out for Australia, but are captured by black cannibals. Brown-skinned cannibals rescue them, but in turn sell them to yellow-skinned barbarians who practice socialism. The Great High Priest, however, turns out to be an Englishman who was captured as a child helps them escape by the secret underground river.

The Fortress of Yadasara, a Narrative Prepared from the Manuscript of Clinton Verrall, Esq. (1899) by **Percy Brebner** is another romantic lost-race adventure taken from discovered writings. While hiking in the Caucasus, the Victorian-era hero falls into a hidden land populated by the descendent of the last Crusade. We'll skip the central part of the story, just mentioning that -- as is often the case in such situations -- escape to the outside world is by, yes, an underground river.

The serialized "The Cave of Avarice" by **Clinton Ross**, April 7, 1898, Salt Lace Herald, featured a subterranean treasure trove.

> *To the cave of the underground river I had the casks carried. Then I had a wall built 20 rods from the caves entrance and I walled the treasure there against the roar of the stream that sees no light.*

If the illustration looks vaguely familiar, it's more or less the same as the one in Deering's The Border Boys Across the Frontier in the previous chapter, only from the front, not the back.



THEY DISCOVER THE TREASURE

A Mystery of the Pacific (1899) by **William H. Smeaton** deals with Romans and Atlantilians dwelling under the South Pacific. A bit of the dialog about the subterranean river passing inland.

> *"What is that?"*
>
> *"It is a mysterious underground river, dark and deep, which seems to flow underneath the entire range of mountains. I believe it enters the ranges away to the west, in the heart of a mountainous, impenetrable tract of country covered with dense forest. But for miles and miles this river flows underground. It must go somewhere."*
>
> *"Has it ever been traced to its mouth, or at least to where it leaves the mountains?"*
>
> *"Never. At least I have never heard of any one who followed it up so far, that returned to tell his experiences," was the somewhat alarming remark of Icilius.*
>
> *The river seemed to flow through subterranean valleys and plains, through narrow gorges and beneath the frowning face of sheer impending cliffs. A dull semi-twilight prevailed, amidst which we could discern objects at a great distance both before and behind us. Gems of value almost incalculable sparkled here and there, and by their sheen, even in the dull light, lent their quota to the illumination of the gloom.*
>
> *Now and again we would pass on the left-hand bank the faces of gigantic figures sculptured in the rock. Also mysterious blocks of masonry, showing that mankind had been there before us.*

In "His Enemy's Daughter," Michigan Farmer, April 14, 1900, **Ernest Glanville**'s subterranean stream leads the hero onward.

> *He continued along the passage for some twenty yards, when it terminated in a flight of steps descending at a steep slope into the black well, out of which came the noise of running water. He hesitated here for some time, but finally, plucking up courage, went down, till he stood upon the edge of the underground stream. This he found flowed swiftly along a trough, some three feet in width, hewn out of solid rock. The path followed the stream for a few yards, then suddenly the darkness grew less, and he stood on a sort of gallery above a great underground cavern or chamber, the floor lined with white sand, which reflected a thin stream of light pouring through a crack in the roof. Stepping across the stream to the narrow lip or rock beyond he looked down into the chamber, whose floor was about ten feet below. Then he walked along this natural gallery the whole length of the cave which extended thirty paces, when the stream disappeared into a small opening.*

Josiah Flintabbatey Flonatin, the distinctively-named hero of **J.E. Preston Muddock**'s The Sunless City (1905), chronicles a descent.

> *Flin occupied himself with carefully writing up his diary and examining his instruments. He felt very well satisfied, for so far success had attended his venture, and the theory he had advanced at the meeting had now become actual fact, and he was sailing beneath the surface of a subterranean river.*
>
> *Before him rushed the river which might have been taken for the fabled Styx, and the gloomy caverns the abode of the grim ferryman, Charon... He knew that the rushing river led somewhere, and wherever it led to he was willing to go.*

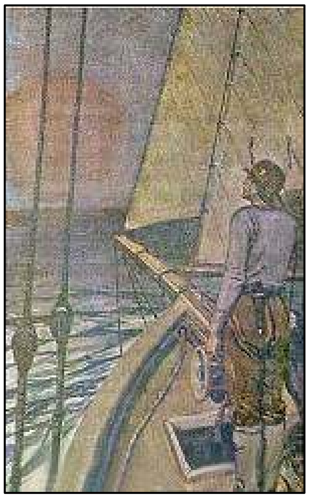
H. Henry Rhodes, Where Men Have Walked, A Story of the Lucayos (1909) begins in a cave.

> *Cautiously I brought my boat nearer the entrance, and I wondered why I had not seen the arch before. But the water was lower now, the tide was out and left clear to view what had before passed as a rock projecting from the ocean's depths. I stepped out on the broad, stone threshold, and gazed around. The water looked black and dismal and bottomless. It was still, not a ripple, for the ocean had no influence here. It could beat its waves against the outside, but could not molest the weird quiet of the waters within, that, in their depths, mirrored the sword-like rocks that hung from the ceiling.*
>
> *A peculiar gurgling sound attracted my attention, and I looked a few feet away from where I stood, to the right, and saw that the waters were disturbed slightly as though a little rivulet made its way over the rocks, down, down the depths below, where it fanned an underground stream.*
>
> *Near the center of the cave, a fountain played, formed by a little stream that bubbled up, sparkling and rippling awhile, for observation, seemingly, then gurgled down into the inner recesses or the earth. A crystal cup rested invitingly near on a ledge of rock, and I advanced to drink. As I drank, the same cooling liquid that had been my salvation when I lay neath the shelter of the rocks, cooled my dry, parched tongue... Could this streamlet, only showing itself for a moment, rippling over the stones for the space at a foot or two, be the same stream that, travelling through the bowels of the earth, became heated almost to boiling, and formed the fabled river that led to hell?*

"The fabled river that lead to hell." By its temperature, it must be the River Pyriphlegethon.

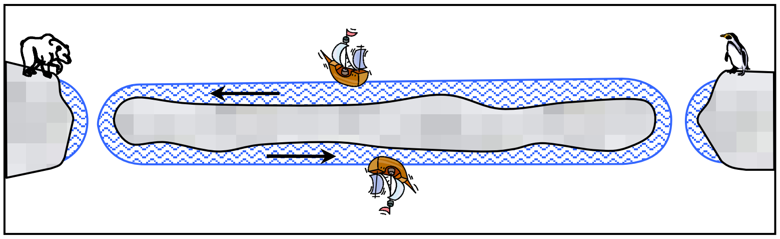
Willis George Emerson's The Smoky God, or a Voyage to the Inner World (1908) capitalized on Symmes' hollow-earth. Olaf and father are caught in a great polar maelstrom fails (a singularity we know from Chapter 15) which sweeps them 10 miles downward. Their compass fails (the other singularity) and the two mariners discover that the seawater is now fresh. How the water can pass around the verge, but not the salt, isn't explained.

For two years the two live with the hollow earth inhabitants whose capital is surrounded by four rivers taking their source from an artesian fountain.



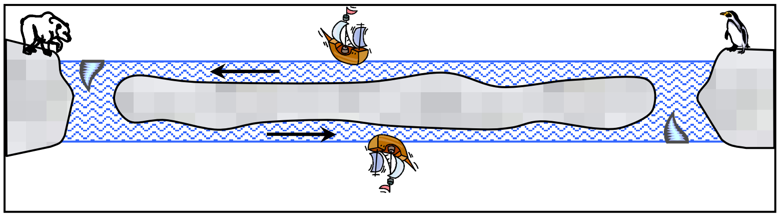
When time comes to bid adieus, Olaf and father head south, as the wind constantly blows from the north. The first intimation of their approach to an exit is an island inhabited by 9-ft penguins. The compass again behaves erratically as they ascend the curvature of the opening and the two Norwegians find themselves among the Antarctic ice.

This is the Symmes model (Chapter 14, Hollow Earth Geophysics). Dual polar passageways nicely maintain Plato's balance of nature and from the perspective of mass balance, the scheme is elegant.



Keeping the water on the respective surfaces defies science, but we'll not belabor the issue.

Other authors have described the passages as vorticies, the topic of Chapter 15. Unlike an arced descent around a Symmes verge, however, the chance of surviving such a maelstrom would be nil. Poe's MS. Found in a Bottle got the fatal part right



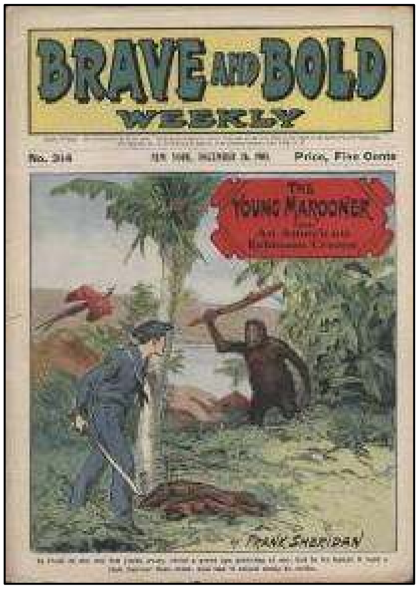
Hydrologic information from the The Smoky God,

> *Some of the rivers "within," Olaf Jansen claims, are larger than our Mississippi and Amazon Rivers combined, in point of volume of water carried; indeed their greatness is occasioned by their width and depth rather than their length, and it is at the mouths of these mighty rivers, as they flow northward and southward along the inside surface of the earth, that mammoth icebergs are found, some of them fifteen and twenty miles wide and from forty to one hundred miles in length.*

At 2,000 square miles, this inner-side iceberg exceeds the largest ever recorded on the outside (off Antarctica) by one-third. The outer-world record holder extended out of the water to almost the height of the Washington Monument.

> *In this garden four rivers have their source in a mighty artesian fountain. They divide and flow in four directions. This place is called by the inhabitants the "navel of the earth," or the beginning, "the cradle of the human race." The names of the rivers are the Euphrates, the Pison, the Gihon, and the Hiddekel.*

The Euphrates, Pison, Gihon and Hiddekel are the Edenic Rivers of Life, Chapter 4.



Sheridan Frank's "The Young Marooner, or An American Robinson Crusoe," Brave and Bold, December 26, 1908, freely lifts from other plots.

Sixteen year-old Tom Scott leaves home and becomes a sailor on a whaling ship. Hanging on to a cable tied to a harpoon buried in a whale, Tom ends up riding atop the whale and being chased by a ravenous giant squid. He passes out and wakes up on the shore of an island inhabited by Joco, a Friday-like character. Tom and Joco discover a mysterious well leading to an underground river which tunnels to an adjacent island. There, they save princess Waupango from cannibals, but her people try to kill the heroes. Tom and Joco escape, and with a powerful explosive destroy the tunnel.

Emma L. Orcutt's The Divine Seal (1909) involves lycanthropy, the Arctic, a hollow world with Atlantilian survivors, suspended animation and a baffling cosmology.

> *We knew the crater was not deep; that some time a winding stairway had been made, and that landings, built of wood, or hewn out of the rock, had served as resting places. We also were aware that at the bottom there was a stream of water; its source and mouth had never been found; at least none of the living inhabitants of Heclades had explored the river and there were no records referring to it that seemed reliable... I knew that volcanic eruptions and earthquakes had occurred since then and I believed this stream had an outlet in the known world.*
>
> *Our electric lantern and "dome light" enabled us to see a long distance ahead; we glided down that underground current with no anxiety as to our safety, but with a great deal of curiosity as to the terminus of our trip.*

As with many Boys Club books, the literary verdict wasn't positive.

> *But it fails to grip a responsive imagination in the reader, and all its wonders fall to the ground with a dull thud* -- New York Times Saturday Review of Books, March 12, 1910

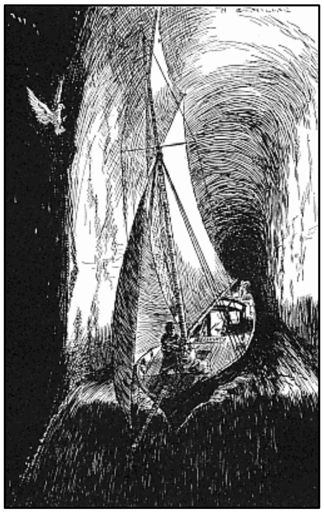
In The Great War Syndicate (1882) by **Frank R. Stockton**, the American War Syndicate fights the British with a "motor bomb" (a rocket fired from a gun), "crabs" (a submarine that snags the propeller of enemy ships) and "repellers" (spring-loaded armor that throws incoming artillery back from where they came). After defeating the Brits, the Syndicate falls into an underground river and must deal with dwarf Indians.

The Adventures of Captain Horn (1910) by the same author presented its hero a puzzle.

> *As he and Ralph stood there, stupefied and staring, they saw, by the dim light which came through the opening on the other side of the cavern, a great empty rocky basin. The bottom of this, some fifteen or twenty feet below them, wet and shining, with pools of water here and there, was plainly visible in the space between them and the open cleft, but farther on all was dark. There was every reason to suppose, however, that all the water had gone from the lake. Why or how this had happened, they did not even ask themselves. They simply stood and stared.*
>
> *In their search for water, game, or fellow-beings, no one had climbed these desolate rocks, apparently dry and barren. But still the captain was puzzled as to the way the water had gone out of the lake. He did not believe that it had flowed through the ravine below. There were no signs that there had been a flood down there. Little vines and plants were growing in chinks of*

> *the rocks close to the water. And, moreover, had a vast deluge rushed out almost beneath the opening which lighted the cave, it must have been heard by some of the party. He concluded, therefore, that the water had escaped through a subterranean channel below the rocks from which he looked down.*

Edith Nesbit's The Magic City (1910) was simply credited to E. Nesbit, as Boys Club boys might not appreciate a lady author. An unhappy 10-year-old escapes into a magical city he has built out of books, chessmen, candlesticks and other household items.



> *He listened. And he heard a dull echoing roar that got louder and louder. And he looked. The light of the lamps shone ahead on the dark gleaming water, and then quite suddenly it did not shine on the water because there was no longer any water for it to shine on. Only great empty black darkness. A great hole, ahead, into which the stream poured itself. And now they were at the edge of the gulf. The Lightning Loose gave a shudder and a bound and hung for what seemed a long moment on the edge of the precipice down which the underground river was pouring itself in a smooth sleek stream, rather like poured treacle, over what felt like the edge of everything solid.*
>
> *The moment ended, and the little yacht, with Philip and Lucy and the parrot and the two dogs, plunged headlong over the edge into the dark unknown abyss below.*
>
> *"It's all right, Lu," said Philip in that moment. "I'll take care of you."*
>
> *And then there was silence in the cavern--only the rushing sound of the great waterfall echoed in the rocky arch.*
>
> *And all the time the yacht was speeding along the underground stream, beneath the vast arch of the underground cavern.*
>
> *'The worst of it is we may be going ever so far away from where we want to get to,' said Philip, when Max had undertaken the steering again.*
>
> *"All roads," remarked the parrot," lead to Somnolentia. And besides the ship is travelling due north -- at least so the ship's compass states, and I have no reason as yet for doubting its word."*
>
> *"Hullo!" cried more than one voice, and the ship shot out of the dark cavern into a sheet of water that lay spread under a white dome. The stream that had brought them there seemed to run across one side of this pool. Max, directed by the parrot, steered the ship into smooth water, where she lay at rest at last in the very middle of this great underground lake.*

Of the pulp-fiction magazines dedicated to the American West, **Old Scout** -- an oft-used pseudom -- wrote "Young Wild West's Leap in the Dark, or Arietta and the Underground Stream," Wild West Weekly, August 17, 1906.

In Darkness and Dawn (1914), **George Allan England** made use of the whirlpool, by then a standard ploy.

> *From the warmth of the sea and the immense quantities of vapor that filled the abyss, they concluded that it must be at a tremendous depth in the earth -- perhaps as far down as Stern's extreme guess of five hundred miles -- and also that it must be of very large extent.*
>
> *Beatrice had noted also that the water was salt. This led them to the conclusion that in some way or other, perhaps intermittently, the oceans on the surface were supplying the subterranean sea.*

> *"If I'm not much mistaken," judged the engineer, "that tremendous maelstrom near the site of New Haven -- the cataract that almost got us, just after we started out -- has something very vital to do with this situation."*
>
> *"In that case, and if there's a way for water to come down, why mayn't there be a way for us to climb up? Who knows?"*

King of the Khyber Rifles (1916) by **Talbot Mundy** was "the most picturesque romance of the decade," according to its press, although Boys Clubs would have been more taken by the adventure.

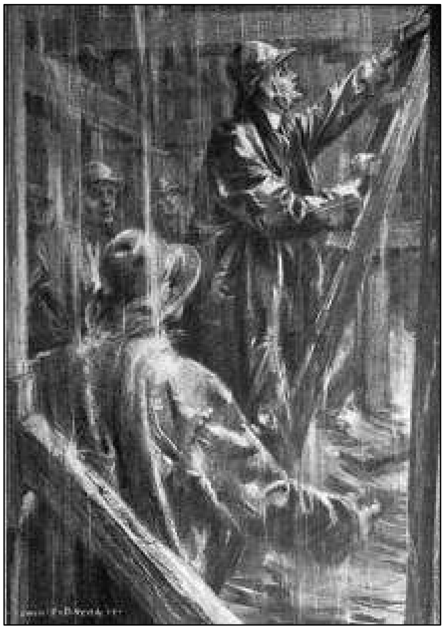
> *There was only one wild scream that went echoing and re-echoing to the roof. There was scarcely a splash, and no extra ripple at all. No heads came up again to gasp. No fingers clutched at the surface. The fearful speed of the river sucked them under, to grind and churn and pound them through the long caverns underground and hurl them at last over the great cataract toward the middle of the world.*

Rex Stout, Under the Andes (1914) tells of brothers and Desiree Le Mire, the most desirable woman in the world, who daringly enter a cave that takes them deep below the Andes.

> *"But where are we? What happened? My head is dizzy -- I don't know --"*
>
> *I gripped his hand.*
>
> *"'Tis hardly an every-day occurrence to ride an underground river several miles under the Andes. Above us a mountain four miles high, beneath us a bottomless lake, round us darkness. Not a very cheerful prospect, Hal; but, thank Heaven, we take it together!*
>
> *"Keep your nerve. As for a way out -- at the rate that stream descends it must have carried us thousands of feet beneath the mountain. There is probably a mile of solid rock between us and the sunshine. You felt the strength of that current; you might as well try to swim up Niagara."*
>
> *We dragged ourselves somehow ever onward. We found water; the mountain was honeycombed with underground streams; but no food. More than once we were tempted to trust ourselves to one of those rushing torrents, but what reason we had left told us that our little remaining strength was unequal to the task of keeping our heads above the surface. And yet the thought was sweet -- to allow ourselves to be peacefully swept into oblivion.*
>
> *Nature is not yet ready for man in those wild regions. Huge upheavals and convulsions are of continual occurrence; underground streams are known which rise in the eastern Cordillera and emerge on the side of the Pacific slope. And air circulates through these passages as well as water.*
>
> *I lay on a narrow ledge of rock at the entrance to a huge cavern. Not two feet below rushed the stream which had carried me; it came down through an opening in the wall at a sharp angle with tremendous velocity, and must have hurled me like a cork from its foaming surface. Below, it emptied into a lake which nearly filled the cavern, some hundreds of yards in diameter. Rough boulders and narrow ledges surrounded it on every side.*

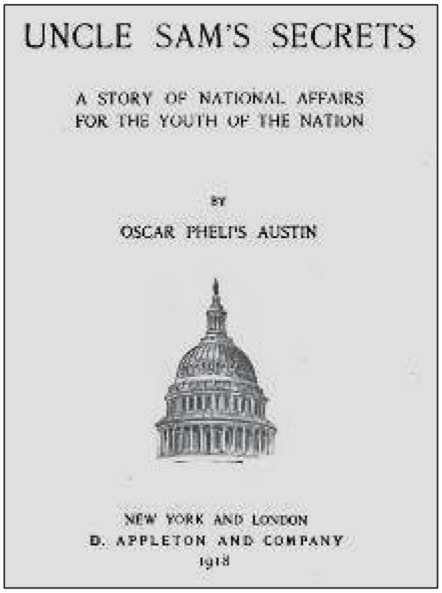
Amidst such fiction we'll insert a couple of works written to edify Boys Club members. Pick, Shovel and Pluck: Further Experiences "With Men Who Do Things" (1914) by **Alexander Russell Bond** provided the Boys Club with appropriate role models

"Fighting an Underground Stream" concerns subway excavation, as what boy wouldn't like to dig in the earth with steam shovels? A near disaster enlivens the episode, but all escape and the work progresses.



Uncle Sam's Secrets: A Story of National Affairs for the Youth of the Nation (1918) provides author **Oscar Phelps** Austin the opportunity to explain many things of importance, America's gold standard and the workings of a postal railway car being two. As for underground rivers,

> *"It seems to me," said the professor, as they bade adieu to the bats, "that I hear the sound of running water; perhaps we shall encounter an underground river. Such things are not uncommon in caves."*
>
> *He was right. A few minutes' walk brought the members of the party to a rapidly flowing stream, which issued from an opening in the side of the cavern, flowed along the passageway for some distance, gradually widening until it covered the whole floor, and then with an abrupt turn disappeared through the side of the cavern.*
>
> *"Dear me," said Mr. Canby, "we shall not be able to go farther."*



UNCLE SAM'S SECRETS

A STORY OF NATIONAL AFFAIRS
FOR THE YOUTH OF THE NATION

BY
OSCAR PHELPS AUSTIN

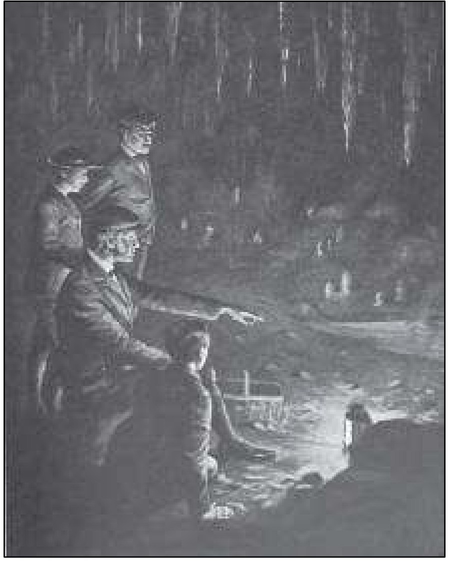
NEW YORK AND LONDON
D. APPLETON AND COMPANY
1918

> *"Wait a bit," said the professor. "I must see about the strength of the stones which project over the water. I can not consent to your taking any risks, for I consider myself responsible for your safety. The water in this river is evidently deep, and, should anybody fall into it, he would be swept underground in an instant and lost."*
>
> *"Where does the water go?" said Mr. Canby.*
>
> *"Probably it flows into the Ohio or some of its tributaries at some unknown point; perhaps it comes into it under the surface of the water, or else at some obscure spot where its reappearance on the surface of the earth has not been observed."*
>
> *"Couldn't we write a letter and send it down the stream in a bottle, so that the people who find it would come and help us out?" said Jimmy. "I have heard of such things happening."*
>
> *The professor smiled. Even in the presence of the immediate danger the smile somehow reassured the others.*

> *"We could send the bottle," he said, "but I don't think we could depend on its bringing a party of rescuers. It might be days or weeks before the bottle would attract anybody's attention, and meantime we should starve, for we have not even a day's provisions with us. Even our light would last but a few hours, and in darkness and hunger we should surely perish."*

> *This part of the cave," said he, seating himself as calmly as though he were in his chair in the schoolroom, "was probably formed in part by the washing and friction of gravel and sand poured over it by the water coming through that opening above us. We are now under a portion of the land which was covered by the great lake caused by the huge ice dam formed across the Ohio River during the glacial period in North America."*

The professor is incorrect regarding the genesis of the cavern, as abrasion can occur only in a channel already large and steep enough to have high velocities. Like all karst rivers, this one was by dissolution.



Everett McNeil, The Lost Nation (1918) features Aztecs, Toltecs, ape-men and subterranean monsters.

> *"Now," and Ith turned quickly to Professor Kendal, "Exitl calls and we must hasten. Look not down and follow me without fear, though I appear to be walking on air. From this point a narrow bridge hangs suspended from the ceiling of the cavern, far above the horrors below, and passes over the river of burning brimstone, even to the Cavern of the Great Jaws of Death."*

H.P Lovecraft's short story, The Beast in the Cave (1918), tells of a man lost from his tour group and stalked by a wild beast in the bowels of Mammoth Cave, a place we will visit in Chapter 50, Then, Madam, You Should Go and See the Great Cave in Kentucky.

No Boys Club member would admit to being scared, even by Lovecraft's "The Festival" in Weird Tales, January 1925.

> *And then, because that nightmare's position barred me from the stone staircase down which we had come, I flung myself into the oily underground river that bubbled somewhere to the caves of the sea; flung myself into that putrescent juice of earth's inner horrors before the madness of my screams could bring down upon me all the charnel legions these pest-gulfs might conceal.*

Abraham G. Merritt, The Moon Pool (1919) features a South Sea escape from reptilians.

> *Whence came the stream, I marveled, forgetting for the moment, as we passed on again, all else. Were we closer to the surface of earth than I had thought, or was this some mighty flood falling through an opening in sea floor, Heaven alone knew how many miles above us, losing itself in deeper abysses beyond these?*

"The Flying Legion," All-Story, November 15, 1919, tells of the Master (a soldier of fortune), the mysterious masked Alden (a female in disguise) and the Legionaries who enter the hidden city Ruba al Khali, discover a pyramid of solid gold and in fighting their way out, leap into an underground river which delivers them to a perilous desert.

In **Ella M. Scrymsour**'s The Perfect World, A Romance of Strange People & Strange Places (1922), purple-skinned one-horned descendents of the Korahites, swallowed by the earth for rebelling against Moses.

> *Tirelessly he worked, until success met his efforts and he had made a hole big enough to crawl through, and from whence came the sound of rushing waters.*
>
> *He lifted his lantern above his head in his endeavor to discover where he was, and its feeble rays shone upon a swiftly flowing, subterranean river that disappeared through a tunnel on either side. The place he was in was very small and had no outlet except by way of the water.*
>
> *The river was narrow, perhaps four feet wide at the most, but with a current so strong that Alan, good swimmer though be was, would not have dared to have trusted himself in its cruel-looking depths. Mechanically he dropped a lump of coal into the water. There was a slight splash -- but no sound came to tell him that it had reached the bottom.*
>
> *He looked at the water curiously, and dabbled his fingers in the brackish fluid. Suddenly a pain in his hand made him draw it out quickly, and by the light of the lantern he saw it was covered with blood. As he wiped it clean he saw the impression of two teeth on his first and third, fingers. Slowly his lips moved and he murmured, "There is animal life in this river then-I wonder where it leads-can there be humanity near too?"*

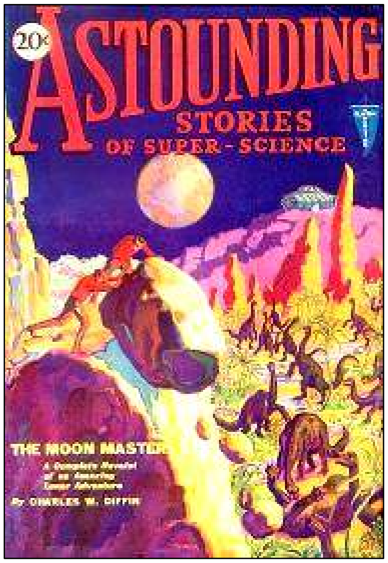
Soviet geologist and geographer, explorer, and indefatigable popularizer of scientific knowledge, **Vladimir Obruchev** wrote Plutonia in 1924. A comet knocks a hole in the earth's shell, permitting access into an underground world of rivers, lakes, volcanoes and strange vegetation, a world with its own sun -- Pluto, a world inhabited by monstrous animals and primitive people.

Edward M. Forster's 12,000-word The Machine Stops (1928) describes a subterranean world in which almost all humans have lost the ability to live on the surface. Each individual lives in isolation, with all bodily and spiritual needs met by the omnipotent, global Machine. The population uses a "speaking apparatus" and the "cinematophote" (television) to conduct their only activity, the sharing knowledge.

The people forget that they, the humans, created the Machine, and treat it as a mystical entity having whose needs that supersede their own. Those not accepting subordinate to the the Machine are viewed as unmechanical and threatened with expulsion.

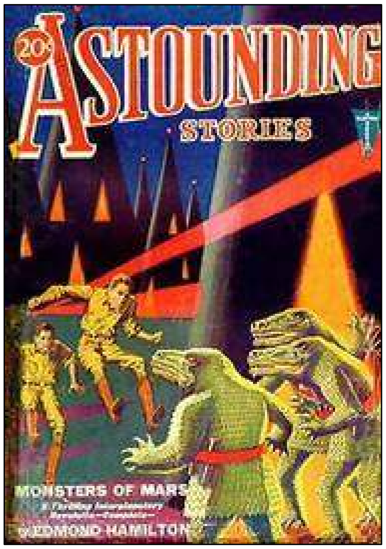
Eventually, defects begin to appear in the Machine. At first, humansHumankind at first accepts the deteriorations as the whim of the Machine, but as the knowledge of how to repair the Machine has been lost, the Machine apocalyptically collapses, bringing civilization with it.

Tom Curry's "Giants of the Ray" in Astounding Stories of Super-Science, June 1930, concerns Super Science, but the underground river is just worldly big one.



> *Madly the Three raced for their lives up the shaft of the radium mine, for behind them poured a stream of hideous monsters -- Giants of the Ray!*
>
> *The mine spread out now, and began a steeper descent. The air was poor, and it was hard to breathe through the mask. Maget, his heart thumping mightily, listened to the roaring within the depths of the mine.*
>
> *Now the ground seemed to drop away before them. Maget could hear the running of water, the underground river, and every now and then there came an immense splash, as if some great whale had thrown itself about in the water.*

"Four Miles Within," Astounding Stories, April, 1931, by **Anthony Gilmore** is saga of terror.



> *They were standing on a narrow ledge that overhung an underground river. A fetid smell of age-old, lifeless water rose from it. Dimly, at least fifty feet across, they could see the other side, shrouded in vague shadows. The inky stream beneath did not seem to move at all, but remained smooth and hard and thick-looking.*
>
> *They could not go around it. The ledge was only a few feet wide, and blocked at each side.*
>
> *"Got to cross!" Phil said tersely.*
>
> *Quade, sickly-faced, stared down. "There -- there might be other things in that water!" he gasped. "Monsters!"*
>
> *"Sure," agreed Phil contemptuously. "You'd better stay here." He turned to the others. "I'll see how deep it is," he said, and without the faintest hesitation dove flatly in.*
>
> *Oily ripples washed back, and they saw his head poke through, sputtering. "Not deep," he said. "Chest-high. Come on."*
>
> *He reached for Sue, helped her down, and did the same for her father. Holding each by the hand, Sue's head barely above the water, he started across. They had not gone more than twenty feet when they heard Quade, left on the bank, give a hoarse yell of fear and dive into the water. Their dread pursuer had caught up with them.*

BLOND GODDESS

A New Serial by Herbert Jensen

"Blond Goddess" was a lightening-paced adventure story by **Herbert Jensen** serialized in daily newspapers in the mid 1930s. We'll extract from the passage in which Frank Grahame, the explorer, may not escape a flooding Yucatan valley via an underground river to the coast. We'll classify it as a single work, as it's just one adventure chopped up.

> *Despite himself, Frank's teeth begin to chatter. He had estimated eight to ten hours immersion would his resistance bear it.*
>
> *Then suddenly the phosphorescent glow disappeared. The water seemed quicker; then apparently the current became a scarcely perceived flow.*
>
> *He touched the side-wall. His senses had not deceived him. The current had indeed diminished.*
>
> *As he splashed forward to assist with the effort of downstream progress, he began to be aware that ahead of him there showed a light that was not the greenish yellow of phosphorous.*
>
> *He could not let himself believe that the grayish dimness that suffused the blackness ahead of him was the end of the cavern. His disappointment, he knew, would be too keen. The clumsy life belt impeded his progress; yet he dared not dispense with it lest some weakness overcome him, or some mishap occur.*
>
> *A vagrant eddy caught him and hurried him forward. He was whirled dizzyingly for an instant. He bumped against a buttress of rock projecting into the channel. The stream made a twist to the left; then to the right.*
>
> *Sudden realization swept him. The underground river discharged here at sea level; but also it plunged into the hidden chasm that could have no outlet except in the floor under that glittering, turquoise sea ahead.*
>
> *The breath gasped in his lungs. Deeper the suction pulled him. He was spun about in the inflexible grip of a whirlpool.*
>
> *Gasping for a last despairing breath, he was shot down a great tunnel. A crashing and roaring sound filled his ears. His body was hammered and flailed against the rough sides of this terrible aqueduct. His lungs were on fire -- no, they were bursting.*

S. Fowler Wright's, The Hidden Tribe (1938) concerns the fortunes of a tribe which has isolated itself for over two thousand years in an oasis, watered by a subterranean river in the midst of the vast barrenness of the Libyan dessert. They are ruled by a race of kings who have continued the ancient Egyptian custom of marrying their sisters, but at the time of this story the destruction of all but one of the royal race renders this custom impossible. As a consequence, an English lass whose "aeroplane" has crashed in the desert finds herself in unwelcome competition with an American girl who has been kidnapped from a Cairo train for the dubious honor of sharing the throne.

> *"There is a river here?" Leonard asked, in a natural surprise. "There is a stream that flows underground."*
>
> *The fault of strata, the consequent outcrop of rocks of different solidity, the presence of subterranean water -- it was all no more than the Western Sahara illustrates a hundred times on a smaller scale, where green oases have resulted, and men have sunk wells to find that abundant water will rise so long as it be kept dear of the choking sand.*
>
> *But this misconception did not alter the importance of the fact that there was a method of contact with the outer world which was known and used. And the channel of this contact was clearly indicated as being the subterranean river. But on the essential point of where and how access had been obtained to it in the far Egyptian desert, Helen Vincent had nothing helpful to say.*
>
> *Somewhere, in the 20,000 square miles of that monstrous and repellent wilderness, there must be access to the subterranean river. But this was a point on which Miss Vincent could give no guidance at all.*
>
> *And, after all, it is better to go to rest on a goat-skin couch than to spend the night clambering in the black bowels of earth, afraid at every moment to be faced by a sudden light and a circle of lifted spears; or to be launched on a subterranean river, perhaps with no light at all (and how*

> *would the place of landing be found under such conditions as that?), and with little food, and dreading that, at any moment, the water might rise, or the cavern roof come down, so that they would bump against it in the dreadful dark, and be scraped off, or choked by the flood as it filled up to the roof above.*

Quoting from the table of contents of **Alaric J. Roberts**' New Trade Winds for the Seven Seas (1942), in the third episode, "Atlantis and Lemuria of the Deep,"

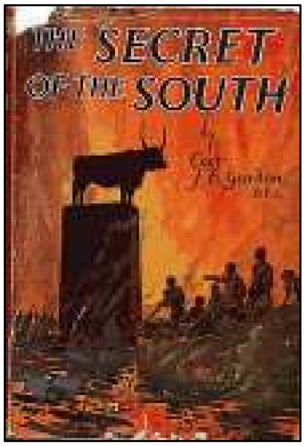
> *A dramatic shipwreck scene takes place, and the survivors escape to Crater Island, where they discover a geological rift causing and underground passage into the gigantic "subtitudes" of the earth's interior.*

We have the pro-forma exploration party for such ventures -- the young and adventurous accompanied by the pedantic professor. A snippet of the explorers' banter,

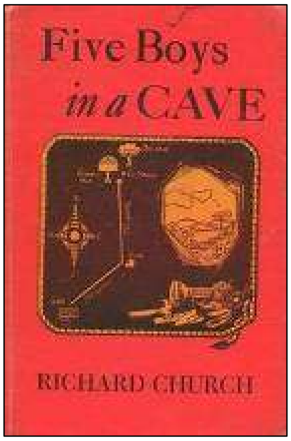
> *"Then one day as we were exploring the lower depths of these endless byways, we were astonished by the discovery of an underground river that must have been several thousand feet beneath the surface. The entire tunnel as far as we could see was covered with a thin growth of luminous substance that radiated light."*
>
> *"That's certainly is a coincidence," said the professor. "I have a friend on the Pacific Coast by the name of Walter Dee, who has written a biography of his life called 'Into the Bowels of the Earth.' He has given an account of his actual experiences beneath the surface of the earth in a gigantic rift, similar to this one, which extends thousands of feet into the ground... They intersected a traverse fault, too, at that tremendous subtitude, and there they discovered an underground river of ocean water. The heat grew so intense at that depth that they were unable to continue their explorations. Comparing Jean's subterranean experiences in France and Mr. Dee's on the Pacific Coast, with our situation here, we may conclude that we, too, may find an underground river further down this corridor."*
>
> *"Our minds must be turned alike," answered Jean jovially, "for during the past week you have astonished me with many deductions that I thought were original with me."*
>
> *"Great minds run in the same underground river," added Gerald humorously.*

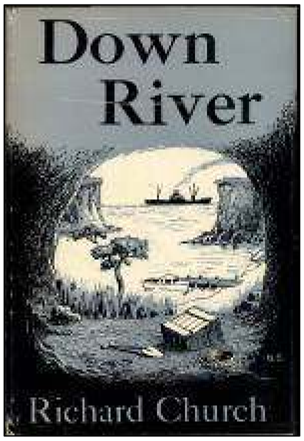
We'll pick up upon the "underground rivers" metaphor in Chapter 29, but this passage would be one of the very few in English literature combining literal and symbolic employment.

In **J.E. Gurdon**'s The Secret of the South (1950), explorers from the upper world discover a lost white race, the Polarians, battling the Neanderthal-like Anthropians beneath the Antarctic icecap. Note the cover's ominous watery setting.



In **Richard Church**'s Five Boys in a Cave (1951), young John Walters discovers the entrance to the limestone cave and invites four buddies to explore with him. They find their way out along a subterranean river. In the sequel Down River (1958), John Walters and the Tomahawk Club set out to explore another underground river, meet a gang of rival boy explorers and foil smugglers hauling contraband to a waiting vessel.


Five Boys in a CAVE
RICHARD CHURCH


Down River
Richard Church

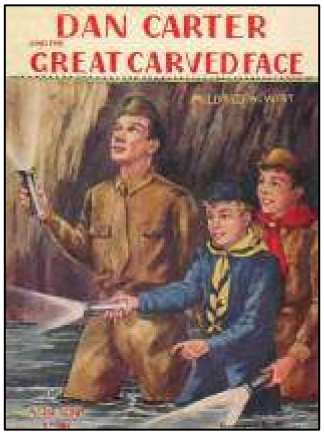
Secret of Stygian River (1951) by **Elbert M. Hoppenstedt** is set in a Kentucky cavern having an underground river. Spelunker Martin Gillis discovers a map and coded message which seems to point to silver bars hidden before the Revolutionary War. Martin's discovery saves the old Gillis farm from destruction in the path of a new highway.

We'll visit the cave which likely inspired this setting in Chapter 50, Then, Madam, You Should Go and See the Great Cave in Kentucky.

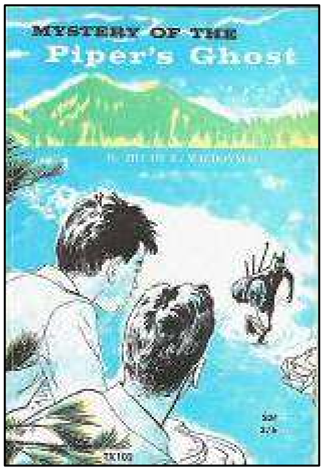
Secret of Stygian River
ELBERT M. HOPPENSTEDT

The cover of Dan Carter and the Great Carved Face (1952) by **Mildred A. Wirt** shows a Scout Leader, a Boy Scout, and Dan in Cub regalia, hip-deep in an underground stream.

More heroic than the plot is the female author, affixing her true name to the Cub Scout series.

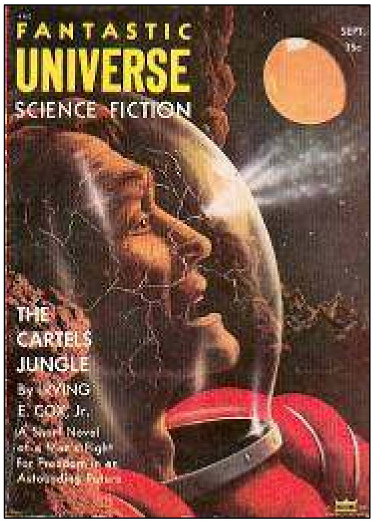

DAN CARTER AND THE GREAT CARVED FACE
MILDRED A. WIRT

The Mystery of the Piper's Ghost (1954) by **Zillah Macdonald** involves a mysterious bagpiper rising out of a Nova Scotia lake. Our boys suspect that this relates to a secret gold mine and become lost in the tunnels.



Emerging, a la Sinbad, from a cave river into a strange world is a standard ploy in Boys Club fiction. In the American-Czech hybrid film Journey to the Beginning of Time (1955), four boys row into a cave in New York's Central Park and emerge into a prehistoric world. After their boat is crushed by a dinosaur, they travel yet further back in time on a makeshift raft and themselves begin to become primitive. In mythology fashion, they at last return to the sea. , The film was serialized into 5-minute chapters for U.S. television.

A Hollow-Earth passage via Brazil has long been speculated (Chapter 14, Hollow Earth Geophysics), something which may have been of use to the Nazis. Consider "Operation Earthworm," Fantastic Universe, September 1955, by **Joe Archibald**



> *"For the last seventy years, all we have thought about was outer space... I am announcin' for the benefit of the press and everybody from here to Mars and Jupiter and back that I intend to explore inner space! I have already got the project underway...*
>
> *The Magnificent Mole is built mostly of titanium, a metal which is only about half as heavy as steel and twice as rugged. It is not quite as big in diameter as the auger, for if it was any Martian moron knows we would scrape our sides away before we got down three miles...*
>
> *Whir-r-r-r-r-r-r-r-r-r-o-o-om! The Mole shudders like a citizen looking at his income tax bite and then starts boring. There is a big bright light all around us, changing color every second, then there is a sound like all the pneumatomic drills in all the universe is biting through a thousand four-inch layers of titanium plate...*
>
> *I look at the instrument panel again and see we are close to being seven thousand miles down, and all at once the gauges show we are out of energy. I look out the port and see a fish staring in at me, and a crab with eyes like two poached eggs swimming in ketchup.*

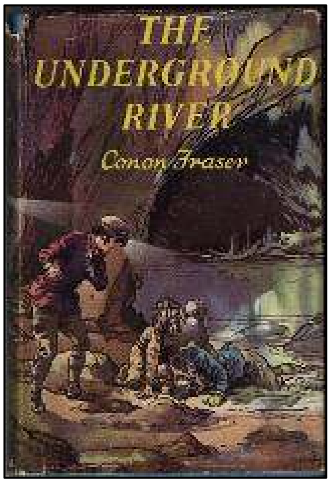
> *Then we are going through dirt again and all of a sudden we come out of it and I see a city below us all lit up and the buildings are made of stuff that looks like jade run through with streaks of black.....*

Encountering a nefarious subterranean dweller,

> *"Come, schwine," the creep says. "I will show you something... I am Agrodyte Hitler, grandson of the Liberator."*
>
> *We walk up a long flight of steps and come to a cadaver memorial and on the front there are big letters and numerals in what looks like bloodstone that says: ADOLPH HITLER, 1981.*
>
> *"He escaped in a submarine, bringing three of Nazi Germany's smartest scientists with him. He brought plans showing us he could split the atom. He brought working models." The creep laughs mockingly. "We have certain elements down here also. Puranium, better than your uranium. And pitchblende Plus Nine. It will power our fleet of submarines that will conquer Earth... We will leave through the underground river that our benefactor found three miles below the surface of the ocean near Brazil. It spirals down through this earth and empties into Lake Schicklegruber eighty miles from here."*
>
> *He looks at me, and then goes on: "We will proceed to the lock that will raise us to the underground river and cruise along its course for a few hundred miles. It is the treat I should accord such distinguished visitors from the outside of Earth, nein?"*
>
> *The skipper of the Subterro sub pulls a switch and there is a noise like three contented cats purring. The metal fish slides along the surface of the underground lake and comes to a hole in a big rock ledge.*
>
> *We see all this through a monitor which registers the scenery outside the sub within a radius of three miles. The sub slides into the side of the rock, and then is lifted up to the underground river that winds and winds upward like a corkscrew to the outlet under Brazil.*

Drawn by the mystery revealed through holes cut into the pages of The Darkness of the Night (1956), **Bruno Munari** leads the reader through the darkness, into the meadow and then into a mysterious cave where an underground river flows and walls tell stories.

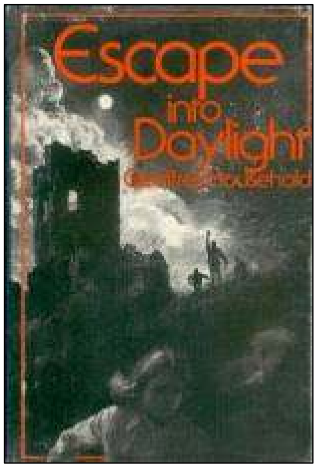
Conon Fraser's The Underground River (1959) is set in the Mendip district of Somerset, home to Wookey Cave (Chapter 51, The Tourist Trade Worldwide). That's an underground lake in the center.



Trevayne (1973) by **Robert Ludlum** was published under the pseudonym Jonathan Ryder, probably to preserve the author's reputation, but it does contain a nice passage.

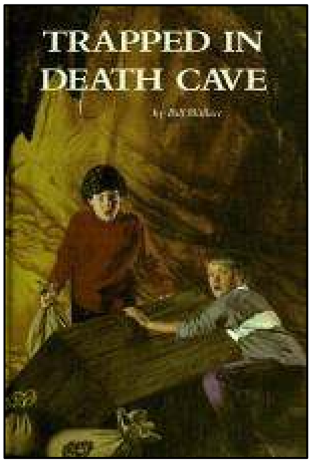
> *Yet now, as he stared down at the Genessee notebooks piled beside the folder newspaper, he found himself strangely reluctant to plunge back into the work he'd set aside three days ago. He'd traveled to and from his River Styx. Like Charon, he'd carried the souls of the dead across the turbulent waters, and now he needed rest, peace. He had to get out of the lower world for a while.*

In Escape into Daylight (1976) by **Geoffrey Household**, Carrie and Mike are kidnapped and imprisoned in a dark, damp dungeon beneath a ruined abbey. The only way out is through twisted passages and an underground river.



Trapped in Death Cave (1984) by **Bill Wallace** qualifies as Boys Club literature by virtue of being in the Weekly Reader "Just for Boys" series.

> *They were in the big cavern. The trough that Brian had followed into the cave was filled with water. Like a river, it wound and twisted its way through the big room.*



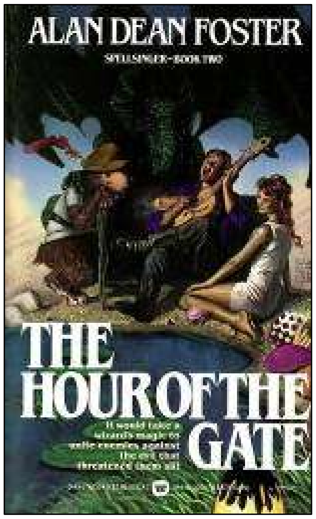
James P. Blaylock's The Digging Leviathan (1984) mechanical "subterranean prospector" was inspired by Edgar Rice Burroughs' At the Earth's Core. The Subterranean Car we encountered in Fred Thorpe's In the World Below, able to drill through the earth completely, was a more powerful machine of excavation, however.

The subterranean prospector is enough to navigate sewers connected to an underground river from there to an underground sea stretching from the Pacific Ocean to the Inland Empire where Chinese junks ply their illicit trade and enormous creatures from past ages yet survive.

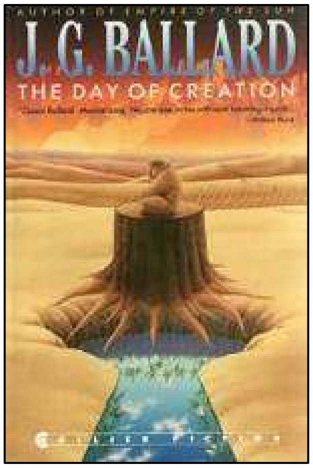
Note the cover. It's what any Boys Club would love to build in their No-Girls-Allowed Invention Shop.

JOURNEY TO THE CENTER OF THE EARTH
JAMES P. BLAYLOCK
THE DIGGING LEVIATHAN

The Hour of the Gate (1984) by **Alan Dean Foster** scores low for plot, but above-average for style. Defending against monstrous insectoids, Jon-Tom and his otter companion embark on an underground river to the spider-silk city of the wary Weavers and their horrifically attractive arachnid queen.


ALAN DEAN FOSTER
SPELLSINGER—BOOK TWO
THE HOUR OF THE GATE
It would take a wizard's magic to unite enemies against the evil that threatened them all

> *"How far into the mountain does the river go?"*
>
> *"Nobody knows," said Bribbens. "Leagues, maybe weeks worth. Maybe only a few hours."*
>
> *"Where does it end, do you suppose? In an underground lake?"*
>
> *"Helldrink," said the boatman.*
>
> *"And what's Helldrink, Senor Ranac?"*
>
> *"A rumor. A story. An amalgam of all the rears of every creature that navigated the waters in times of trouble, during bad storms or in leaking ships, in four harbor or under the lash of a drunken captain. I've spent my life on me water and in it. It would be worth the trip to me if we should find it, even if it would mean my death. It's where all true sailors should end up."*
>
> *It was odd, Jon-Tom mused as they drifted onward, to be moving downstream and yet towards mountains. Rivers ran out of hills*



In **J.G. Ballard**'s The Day of Creation (1987), a stretch of African desert is transformed by an underground river accidentally brought to the surface by a mentally-deteriorating English physician. The doctor, who identifies himself with the river, embarks on a stolen ferry, journeying towards its source in a voyage that echoes Joseph Conrad and Herman Melville.

Well, okay, perhaps it doesn't echo Conrad and Melville, but would like to.

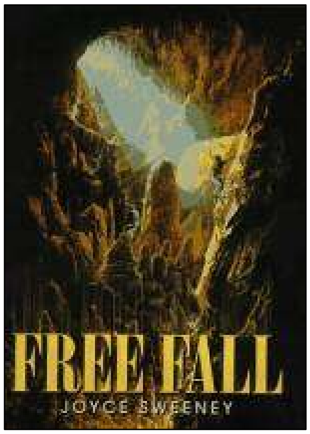
STINGRAY
SUBTERRANEAN SEA

From **Graham Marks**' Subterranean Sea -- Stingray (1992),

> *What mysteries lie beneath the earth's crust? A team of scientists call upon Stingray's crew to investigate. Trapped in the unchartered waters of a vast subterranean sea, Troy Tempest must find an escape route before their oxygen runs out.*

Indiana Jones and the Unicorn's Legacy (1992) by **Rob MacGregor** employs the dive-into-the-underground-river escape familiar to Boys clubs, but it's not Indy's who gets away. As a graduate student in France, Junes goes on a dig and discovers a flooded cave containing Ice Age paintings and clay animals. The nefarious Roland Walcott tries to steal the glory, but disappears into an underground river during a struggle and is presumed dead. He isn't.

Free Fall (1996) by **Joyce Sweeney** is about four boys who go cave exploring. Finding an opening in the cave ceiling, one of them attempts to scale the wall, but falls and breaks his leg. They finally escape by swimming underwater.

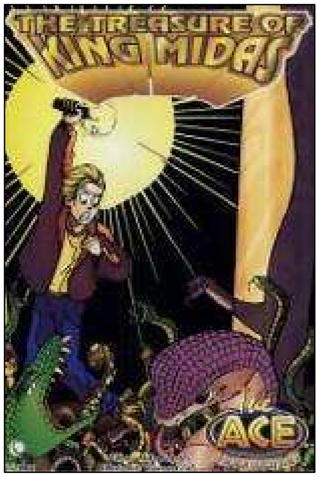


Many of **Clive Cussler**'s adventure novels find action underground. Inca Gold (1994) takes readers on a wild ride on an underground river in search of treasure.

In Free Fall (1996) by **Joyce Sweeney**, our boys find a cave, go exploring, get lost and discover an opening in the ceiling. Attempting to scale the wall, one falls and breaks his leg. They finally escape by swimming underwater. Male bonding.

The Treasure of King Midas (1999) by Mike Kingsley

> *Brian was standing on a narrow ledge like a wharf. Just beyond them, floating on what looked like an underground river, was a small flat bottomed boat. What could it mean?*
>
> *"AEEEGGGGHHHH!"*
>
> *"What is it?"*
>
> *"A man. Right there."*
>
> *It was a human figure, dressed in a long black cloak, holding a sickle. The other hand was stretched out toward them.*



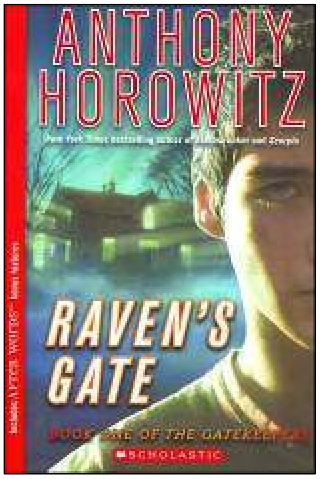
And a bit later,

> *But the news was not good. Where they had come down from the mountain above, through the maize, down to the underground river to the boat cave, there was nothing but a wall of rubble. Carbunkle had done his job too well.*

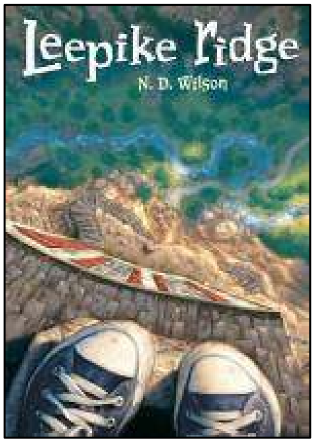
Raven's Gate (2005) by **Anthony Horowitz** includes the standard escape-via-underground-river sequence when Matt and Marsh flee Omega One by jumping into such a river under the building.

More interestingly in a later discussion regarding a nuclear reactor, an underground river use we'd not realized.

Richard Cole:	*Why did you build it in the middle of a wood?*
Sir Michael Marsh:	*Well, it had to be somewhere out of the way. And there's an underground river that runs through the wood. That was the main reason. A nuclear power station requires a constant supply of water, you see.*

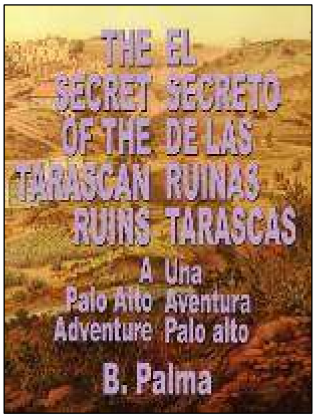


In Leepike Ridge (2007) by **Nathan Wilson**, 11-year-old Tom is dragged deep underground by a swift river, finds himself trapped in a world of labyrinthine tunnels, freezing subterranean rapids and relentless darkness. He pulls himself onto an island, but as there is no food, he's compelled to try his luck in the river again. He ends up in the net of someone trapped for years inside the mountain.



In The Secret of the Tarascan Ruins (2007), one of the bilingual Palo Alto Adventures by **Beverly Blount de Pérez Palma**, Carlos discovers the secret of the underground river by venturing into a waterfall tunnel.

The secret-territory-behind-the waterfall device is somewhat common in adventure fiction, e.g. the Ithilien Rangers' hideout behind such a waterfall in the 2002 movie adaption of Tolkien's Lord of the Rings, The Two Towers.


THE SECRET OF THE TARASCAN RUINS
EL SECRETO DE LAS RUINAS TARASCAS
A Palo Alto Adventure
Una Aventura Palo alto
B. Palma

The Odyssey (2007) by **Elena Dorothy Bowman** has little in common with Homer's original. From the first chapter,

> *When the dam above the town was built, it changed the course of a river flowing underground, and up to now had never been a problem. People knew it was there and had once inundated their neighborhood, but most days never gave it a thought. Now, however, once the dam was breached the huge flood of raging water rushing through the town was instrumental in rerouted* [sic] *the underground river back to its original course and in so doing was responsible for the creation of a large sinkhole to emerge in the back lot of the land belonging to the Knights.*

What is in common with Homer's world are the underground river and -- as we will see in Chapter 40, the sinkhole.

And there's Fallout (2007) by suspense-master **Tom Clancy** and **David Michaels**.

> *Now Fisher heard something else: the gurgling rush of water.*
>
> *A river. An underground river.*
>
> *He loosened his grip slightly and let himself drop toward the ground until he could see the bumper. The truck's headlights were still on, casting a white glare along the cave walls.*

This by the acclaimed Tom Clancy? On further inspection of Fallout's cover, we realize that Clancy contributed the idea and Michaels did the writing.

But let's not leave the Boys Club before recognizing that an active club did more that read tales of daring. Consider "More about Pickett's Cave" from the April 30, 1881, issue of Scientific American.

> *"The Boys' Exploring Association," to whose diligence this discovery is due, is an organization of young mountaineers living in the vicinity of Pikes Peak, whose laudable purpose it is to combine the enjoyment of camping out with the study of biology, geology, and mineralogy, amid the hills and valleys of that remarkable region.*
>
> *The presence of extensive beds of ocher indicated that the subterranean stream flowed from the granite mountains above, fringing the decomposed materials of the feldspathic rocks in the form of these ferruginous clays, which are so hard and compact as to take a fine polish.*

The boys saw the falsity of the prevailing opinion -- based on the beach-like roundness of cave pebbles -- that the cavern was once ocean washed, in view that its karst genesis could have only happened since the region's elevation.

> *The swirling of a subterranean stream could round the fragments of granite into pebbles as readily as the wash of waves.*

Boys Club enjoy exercises in deduction.

CHAPTER 22
BOYS' LIFE

The most durable Boys Club serial is, of course, Boys' Life, the more-than-a-century publication of the biggest Boys Club of them all, the Boy Scouts of America. We've selected 19 issues to illustrate the broad spectrum of ways in which underground rivers are employed in literature written for youth.

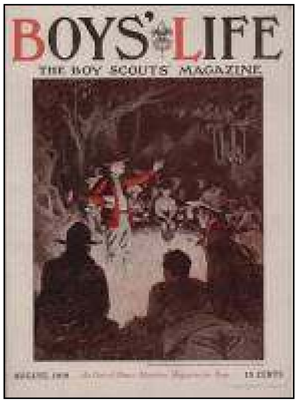
BOYS' LIFE
THE BOY SCOUTS' MAGAZINE
JUNE
10 Cents
When You Go In Camp

June 1915

"The Moonshiners in the Jungle"

Were it not for an occasional glimpse of the stars through the leafy roof over the creek, we might easily have imagined ourselves moving down some mysterious subterranean stream.

We'll see underground river allusions employed to evoke a sense of drama and about everything else in Chapter 29, The Underground River as Metaphor.



August 1919

"Boy Scouts in the Wilderness"

Diving deeply as possible and swimming down with all their strength and speed they shot past the rock and the bottom and into the dim, green depths of the shaft below. As they turned to come up in the clear water they caught a glimpse of what seemed to be a cave opening into the side of the shaft. There was a dare-devil streak in Will's make-up and without stopping to count the cost, he shot into this slanting opening believing that the cave led up into the heart of the mountain above the level of the pool.... If the opening reached the air above, the boy's breath would just last long enough to bring them up...

Not in accord with Boy Scout Manual regarding safety.

BOYS' LIFE
THE BOY SCOUTS' MAGAZINE

April 1920

"The Cave of the Golden Dragon"

Something more than an hour afterward they were standing in the great cave of the golden dragons... Besides finding conclusive evidence that it was the headquarters of the opium smugglers, they had also come upon a number of ingenious modern improvements, such as the electric dynamo Larry suspected...

"Fu-chong was responsible for those, of course," observed Captain Curtis. "No doubt he discovered the place and adapted it top his purpose. I'm inclined to think, though, that as a whole it existed when the monastery up there was in its prime. That bronze trap letting down into the underground river is old as the hills. So are those golden dragons, aren't they?"

Pulp fiction of the era, reference to an underground river adding to the mystery.

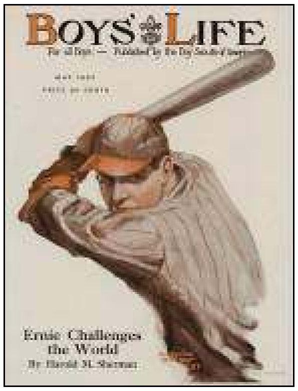
BOYS' LIFE
THE BOY SCOUTS' MAGAZINE

March 1923

"In the Quarry Pit"

The floor of the quarry had disappeared, and he could see nothing save only the sullen black water. He glanced at his watch -- it was a quarter past two, just, and Bob made a hasty calculation. His last shots had opened a seam in the rock; the quarry was filling from some spring or some underground river, and at the rate it was coming -- for the quarry floor was uneven, and he stood upon the highest point -- it would be ten feet deep my morning.

Preposterous portrayal of an underground river vented to the surface by a stray bullet.



May 1927

"The Secret of Sprit Lake"

They locked up the cabin and, entering the canoe, headed down the lake.

"Wonder what makes it so regular?" pondered Huston, as the cone-like peak came into view. "It's shaped just like a dish of ice-cream poked out of one of those nickel things that aren't ever big enough."

Tex laughed. "If I could tell you that I'd be drawin' good money in one o' these here colleges," he returned. "Some say that thousands of years ago this was a volcano and the island might have been the peak, sunk down sort of. The lake must be fed by springs or some kind of an underground river, for it hasn't any inlet or outlet, and the water level always stays the same.

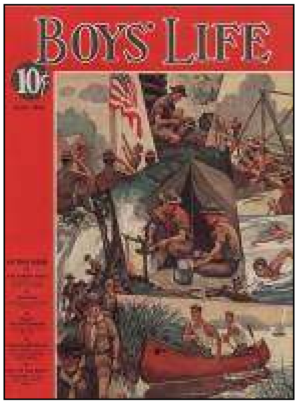
Sprit Lake has the appearance of Oregon's Crater Lake, but the latter's hydrogeology isn't particularly subterranean.

April 1930

"Mississippi Miles"

The sound of a rushing current as distinctly to be heard. They went ahead, with renewed caution, careful where they set their feet, using their elbows to brake themselves as they went slowly down the rough stairway hewn in the rock... The noise of the steam became louder, though it sounded somewhat muffled. The cause for this became plain when they halted at length on the brink of a great split that ran sheer across their path, stretching far on either side. Deep down in this black abyss ran the subterranean stream. The gap averaged ten feet in width. Into it they must have inevitably plunged had they lost footing. Miles shuddered as he realized how nearly Wild Bill had come to ending his life.

In subsequent chapters we'll encounter numerous references to the sounds of subterranean streams.

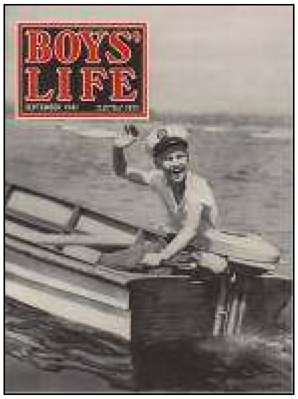


June 1938

"Porky, the Outboarder"

"My partner's right," endorsed Mr. Jordan. "Don't you boys put too much line out and the muskallonges won't bother you. You've got to fish deep for babies like that. They say they come into Cedar Lake from the Great Lakes, through an underground river and that's why you can't find bottom here in some places."

Chapter 78, Beneath the Great Lakes, will have more to say regarding such fish.



September 1941

"Golden Peril"

"Looks pretty dark inside," Peter said, taking out a candle. "What I don't understand is, where's the lake? Ought to be one, according to the map. A pretty big one, too. 300 yards by 500."

"And 20 fathoms, that's 120 feet, down," Steve added. "Must be underground, if at all."

"Under water, too," Peter pointed to a large circle on the map. "See how it extends beyond the shore. Seems screwy to me. Still, I've heard of underground rivers. Maybe there could be a lake down there, fed by subterranean streams. With a rock roof above where it spreads out under the bed of the ocean."

Cross-section reminiscent of Kirchner, Chapter 8.

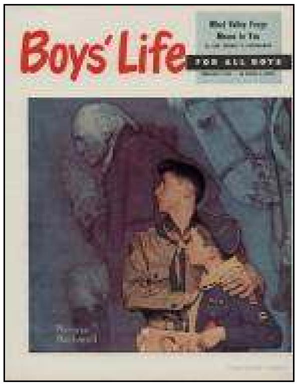
August 1948

"Scout Cavemen"

We boarded a sightseeing boat and paddles across a dammed-up lake and into the cave mouth, which was as big as a railroad tunnel. A few hundred yards upstream we found a group of patrolmen seining the underground river for the lost cave owner. They advised us to go back.

After another thousand yards we reached the head of the river, a small pond in the corner of the biggest room we ever found under the earth.

An account of Explorer Post 2031's excursion to Case Cave in northwestern Georgia. Accurate description of a karst cavern.

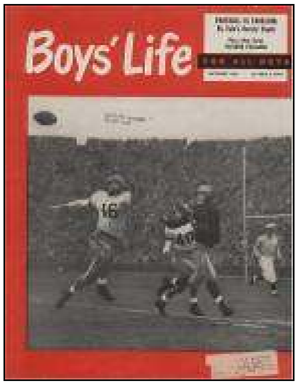


February 1950

"Saulteaux's Lobstick"

"He's Grey Hawk," Conant interpreted. "Says his father wants to get the buffalo-killers lost. Or delay 'em till they are caught. So he's taken' them to the Nyarling -- the Underground River. Which they canna' follow because part of its way it does flow underground through the salty bed rock.

More adventure fiction, but accurate in the description of desert rivers that persist below the stream bed.



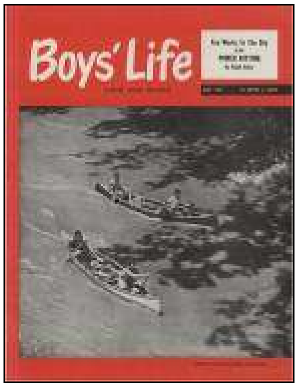
September 1950

"Death Valley Adventure"

The others gathered to hear the park naturalist, L. Floyd Keller, tell a story of how Bad Water got its name from a man who made a mistake.

He was a map-maker, and he found the place many years ago -- a small pool of water standing in a depression of the salt flats. The salt there is 1800 feet deep, but the water, fed by an underground river, runs to a depth of only a few inches. The map-maker tasted it, made a wry face and reported to his bureau in Washington that it was bad water.

Another bona fide report of a Scout outing, the "underground river reference" meaning "spring."

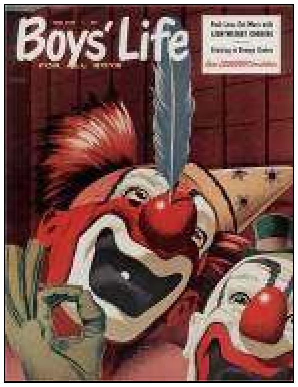


May 1951

"High Water!"

A few hundred feet inside the cave found us in absolute darkness... A hundred feet farther on we found ourselves wading nearly knee deep in a stream of ice cold water which came rushing toward us through the narrow tunnel we were following... Ronnie went up ahead, then came back to announce that the underground stream became a small lake with icy water waist deep.

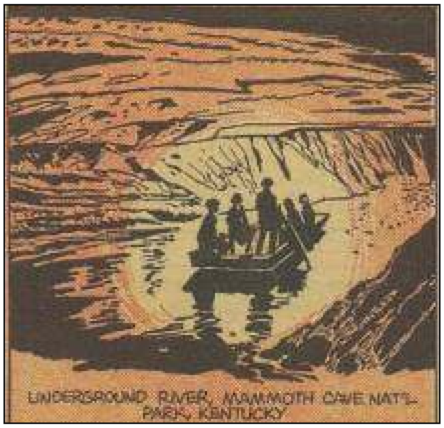
A true adventure, accurate in description of a cave stream issuing from an interior spring.

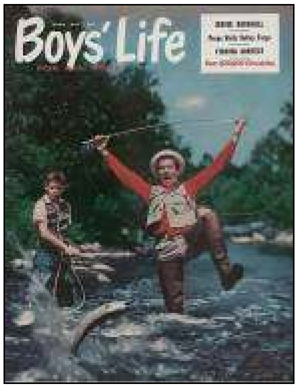


June 1955

"Our National Parks"

We'll see the postcards in Chapter 50, Then Madam, You Should Go and See the Great Cave in Kentucky.


UNDERGROUND RIVER, MAMMOTH CAVE NAT'L PARK, KENTUCKY

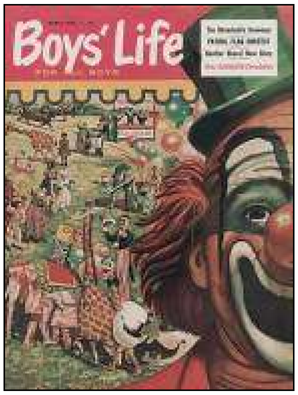


April 1957

"Terror in the Temple"

The boy in the village, half dead from the trip through the underground river, had done it. Driving with all he had left, Joe fought clear of the pool's embrace.

The harrowing underground river escape so favored by the type of authors who choose titles like "Terror in the Temple."



March 1960

"So You Want to be a Geologist."

For example, there are geologists who trace hidden underground water sources in regions having precious little water. One method of doing this is with a radioactive tracer. A water-poor area may have an underground river flowing beneath it. If engineers could plot the hidden course of the river, they could tap the underground water by installing pumping stations along the path. The geologist helps in this task by pouring radioactive material into a river at the point where it disappears underground. Then with radioactive detection instruments on the surface he follows the underground radioactive current and so plot the course of the river. Geologists do still other kinds of work equally exciting and helpful to men.

"Pouring radioactive material into a river at the point where it disapperas underground." For further interesting experiments, the Scout needed the Gilbert Atomic Energy Kit.

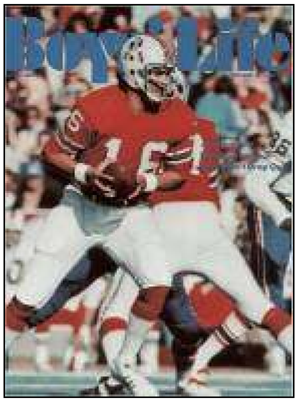
We'll cover groundwater tracers in Chapter 46, Finding the Underground Rivers.

July 1961

"On the Cahokia Pilgrimage"

From the levee the trail winds through a quarry and past a falling spring, appropriately named Falling Springs, where an underground stream pours out about 50 feet up on the side of a bluff.

Non fiction with a common error of nomenclature -- "underground river" again used where the correct term is "spring."



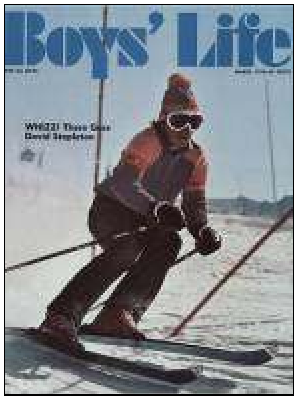
October 1975

"Hiking a Raft Down the Underground River"

The raft of inner tubes, canvas, and plywood lurched forward a few feet in the murky water -- then ground to a halt on the sandy bottom of the Salinas River.

"So this is why it's called an underground river," Brian Dana said. For the tenth time in 15 minutes Brian, Dan Dutra, and Byron Foster jumped from the deck of the raft and tugged on the craft's towropes.

A wry observer, Scout Brian Dana. We'll see, however, that the Salinas may have a deeper underground tie in Chapter 86, The Rio San Buenaventura.



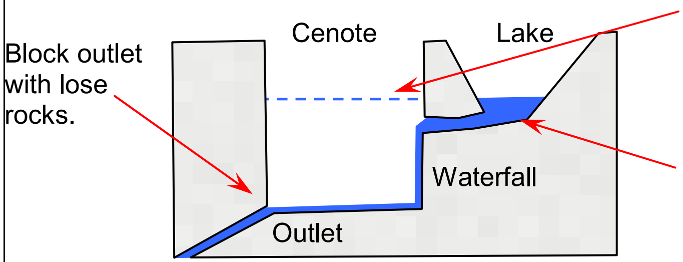
March 1976

"Down the Drain" by Zolton Malocsay

Cenote of the Spirits near the ruins of Tan-Ka in central Mexico.

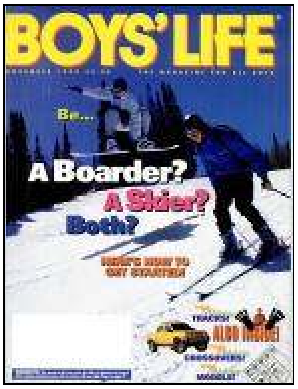
By the time I felt the current, it was too late. I lunged to get away, but the current had me, dragged me deeper under the ledge, into the dark, into the throat of some underground river. I clawed at the ceiling, but my fingernails couldn't hold in the slime. My tanks clonked and scraped, my knees hit rock, my elbows, and suddenly there was nothing but blackness and the rush of water.

The plot's standard Boys Club fare, but the Scout learns how to escape from a vertical-walled cenote having a waterfall from the wall fed by an adjacent lake.



Allow cenote to fill until waterfall is submerged and water level stabilizes. You're now floating at lake level and there's no velocity in the waterfall passage

Escape via a short dive through the waterfall passage.



November 1999

"Hawaiians on Ice"

Prussiking is a technique used to haul yourself up a rope using sliding friction knots. A longer rope has a loop for your feet on both ends; a shorter rope attaches a harness to your climbing rope...

Justin Leong prepares to practice his prussiking skills (see box above).to pull himself out of an underground river.

Factual report of a Scout excursion with misuse of "underground river" in lieu of "crevasse." We'll discuss glacial rivers in Chapter 41, Underground Rivers in Caverns other than Karst.

Although **George Ralphson** didn't write for Boys' Life, we'll include him in this chapter for his Boy Scouts adventure series, the characters of which embody the slogan "Do a Good Turn Daily."

> *To the Boys and Girls of America, in the fond hope that herein they will find pleasure, instruction and inspiration; that they may increase and grow in usefulness, self-reliance, patriotism and unselfishness, and ever become fonder and fonder of their country and its institutions, of Nature and her ways, is the cherished hope and wish of the author.* -- G. Harvey Ralphson, Scout Master

Boy Scouts in Mexico, or On Guard with Uncle Sam (1911)
Boy Scouts in the Canal Zone, or The Plot Against Uncle Sam (1911)
Boy Scouts in the Philippines, or The Key to the Treaty Box (1911)
Boy Scouts in a Motor Boat: or, Adventures on the Columbia River (1912)
Boy Scouts in an Airship (1912)
Boy Scouts on Motor Cycles (1912)
Boy Scouts Beyond the Arctic Circle (1913)
Boy Scouts in California (1913)
Boy Scout Electricians, or The Hidden Dynamo (1913)
Boy Scouts on Old Superior, or The Tale of the Pictured Rocks (1913)
Boy Scouts on the Open Plains (1914)
Boy Scouts in Southern Waters (1915)
Boy Scouts on the Open Plains (1914)
Boy Scouts in the North Sea (1915)

Some of the Scouts' underground river adventures.

From Boy Scouts in Mexico (1911)

> *"Water in wells comes from elevations before it gravitates to the bottom of the holes from which we pump it," Shaw declared, in defense of his suggestion. "There may be a reservoir here somewhere."*

From Boy Scouts in a Motor Boat (1912)

> *Jimmie was not at all averse to a swim, for he did not know how cold the water of the underground stream was. So he tossed his light across, seized the end of the rope Jack had used on his return trip, and leaped in.*
>
> *Then his weakness made itself manifest, for he did not seem to have the power to force his way across in the face of the current. He hung on bravely, but made no progress. Jack threw off his coat and, taking hold of the rope on his side, dropped in and drifted down to the struggling lad.*

From Boy Scout Electricians (1913),

> *"Ned thinks there is an underground stream," Frank suggested, "and I move that we go find it while he is away."*
>
> *Almost before the words were out of his mouth, the boy switched on his flashlight and disappeared in the opening. Frank and Harry were at his heels in a moment, and the three went crawling down an incline of about thirty degrees on their hands and knees.*
>
> *Fifty feet or more from the opening they came to a chamber much larger than the cave in which they had stored the motor car. The flashlights showed a swift current lashing against broken boulders. A few paces below, the stream disappeared entirely, falling over a precipice with a sound which, in that confined space, reminded one of thunder.*
>
> *"Say!" Jimmie shouted, speaking in Frank's ear in order that his words might be understood above the roar of the water, "they've set the stream at work down there and they've forgotten their oil can. Don't you hear the machinery creaking?"*
>
> *From the depths of the stream somewhere below its plunge into unknown regions came the sharp, insistent creaking of an improperly cared for shaft. It sounded to the boys like the nerve-torturing screeches heard from the primitive horse cars in New York.*
>
> *Frank sat down flat upon the ledge and turned his flashlight toward the point where the stream disappeared.*
>
> *"We've got it!" he cried; "we've got it! If anybody should ask you, there's the hidden dynamo right down there, under that current!"*

> *"Anyway," Jimmie went on, "I'm going out in there to see how deep that water is. If it isn't too deep, I can drop down to the boulder above where the water disappears, and get a peek into the chute it follows. I might be able to see if there really is anything except a waterfall below."*
>
> *This plan gained the consent of the boys, and in a short time Jimmie dropped off the ledge and started to swim toward the boulder at the head of the drop. To his amazement, however, he found the water was only up to his waist, so he waded along quite comfortably, although the current was very strong.*
>
> *Once or twice be slipped on the treacherous bottom and plunged head first into the water, but the rope always assisted him to his feet, and he went on until he came to the boulder which split the stream at the point of its disappearance. Perching himself upon the rock, he called out to Frank:*
>
> *"There's a water-wheel down there, all right, and the water-wheel runs the dynamo."*

For Scouts who demonstrate knowledge of underground rivers and carry out an appropriate conservation project, we suggest an Underground River merit badge, a combination of the Canoeing and Geology badges.

CHAPTER 23
GIRLS, TOO!

We'll start, as we did for the Boys Club, with serials and then catch some stand-alones. We can do it all in a single chapter, however, because as a whole, girls aren't as infatuated with underground rivers.

We include stories in which girls and boys together are main characters, rarely a problem for an egalitarian Girls Club. Boys Clubs, on the other hand, tend to post "No Girls Alowd" on their clubhouse door.

Girls Club Serials

Roughly half of Stratemeyer's publications were written for girls under a variety of pseudonyms, but only two of this category contain underground river episodes.

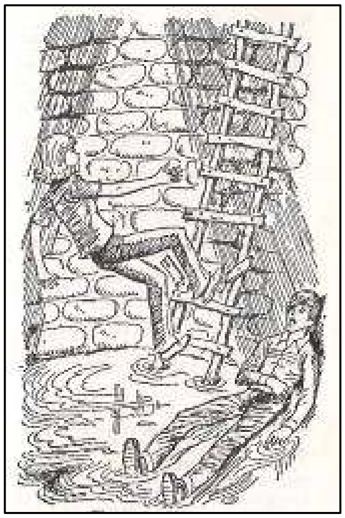
Laura Lee Hope is the pseudo-author of four series written for girls: the Bobbsey Twins, Outdoor Girls, Blythe Girls, and the Moving Picture Girls, 72, 23, 12 ands 7 volumes, respectively. The Bobbsey Twins, were too young for the rigors of underground rivers and the three other girl bunches were into activities deemed more appropriate for girls of their day.

Hoop is also credited with a dozen Make Believe Stories, The Story of a Candy Rabbit (1920), being an example, and 20 Bunny Brown books, aimed at younger children.

Only in Hope's 14-book Six Little Bunkers is there mention of an underground river, and only by deferring to the authority of an elder male. From Six Little Bunkers at Uncle Fred's (1918)

> *"Well, you know there are engineers who make a study of all kinds of water: of springs, lakes, river, and so on," explained Uncle Fred. They are water engineers just as others are steam or electrical engineers. I though I'd ask then for reasons for springs going dry. Some of them may know something about the water in Montana, and they can tell me if there are underground rivers or lakes that might do something to my spring."*

SIX LITTLE BUNKERS at UNCLE FRED'S
·LAURA LEE HOPE·



Carolyn Keene's Nancy Drew Stories, 175 titles between 1930 and 2003, is still a library favorite, and here we have Nancy's sole adventure in subterranean waters, The Secret of the Forgotten City (1975). The title of the French edition, Alice et la Rivière Souterraine, speaks to our interest.

Nancy and the gang join an archaeological dig searching for lost gold. The mystery begins when an Indian visits Nancy in hopes that Nancy can help her translate the petroglyphs on some stone tablets.

> *"I believe I know where an underground stream supplies a small spring that is above ground.*
>
> *"I think the underground stream runs through a mountain, but at one time no mountain was there. Over the centuries sand and dirt have blown across the area and formed a high covering over the stream."*
>
> *Nancy was eager to see the place. "Maybe we can find clues to the treasure in the Forgotten City!"*

In the field,

> *The person most delighted over Nancy's find was Wanna. She looked at the tablet, trying to decide what the petroglyphs meant.*
>
> *Presently she said excitedly, "I believe these pictures prove my theory that there is an underground river with gold nuggets on its shores."*
>
> *Nancy said she could hardly wait to start a search for the stream.*

A bit later,

> *"We stop here," the young Indian student said a little later. "We'll walk down this hill to a water hole, which the Indians say is a spring bubbling up."*
>
> *When they reached the spot, Wanna pointed out what appeared to be no more than a pool of water that came out of the mountain and ran back into it on the other side.*
>
> *Wanna saw the looks of disappointment on the faces of her friends. "You expected more, I know," she said, smiling. "I believe that at one time this was a tributary of the Muddy River. By the way, now it's called the Moapa after the tribe of Indians that live nearby.*
>
> *"I haven't quite figured out just what happened. Perhaps there was a great landslide, and the only spot where the water bubbled to the surface was right here. But that wouldn't have been enough for maybe a thousand people. So they moved out."*
>
> *Nancy asked, "Do you think the Indians needed water badly and might have tried to tunnel into the river so it wouldn't stop running?"*
>
> *"It's a fascinating idea, Nancy," Wanna replied. "Maybe someday we can find out. One thing I do know is that the well where the poor young man lost his life is very close."*
>
> *"Let's not stand around talking any longer," Ned suggested. "Come on, fellows, we'll bring the tools down from the car and see if we can unearth this stream with the hidden gold plates."*

The suspense mounts!

> *Nancy stayed there and took up one shovelful after another of the soil. No interesting items showed up. She kept digging deeper. In a little while the young sleuth reached a very wet place. Was this part of an underground river?*

> *She called to Wanna, who came over. The geologist was excited.*
>
> *"Nancy, I think you've figured out the direction of the underground stream. Apparently it wasn't straight."*

Nancy discovers the river.

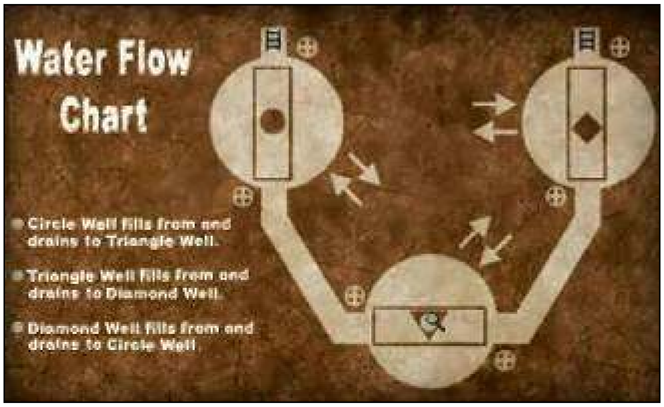
> *When the young sleuth reached the bottom she spotted an object in the wall of the watery tunnel opposite her. Wondering what it was, she tried to reach across. This was impossible.*
>
> *"I guess the only way I can get there is to let myself out of this sling and reach over," she told herself, and slipped from the ropes.*
>
> *Nancy was in the midst of wading across, when there was a rush of water through the tunnel toward her. It knocked the girl over, and the .current swept her along into the foaming tunnel.*
>
> *Nancy never panicked, but now she knew she was in serious trouble. If the tunnel remained as wide as it was, she might be carried outside and be able to save herself.*
>
> *"But if the passageway gets too narrow to carry me through-" she thought. Nancy closed her eyes and prayed.*

And what does he find?

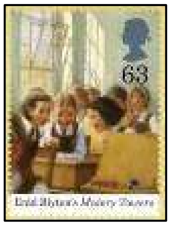
> *Meanwhile Nancy had been swept along the tunnel. She had managed to keep her flashlight on and kept looking for a place where she could stop of find something she could cling to. At first she found nothing, and went on. The tunnel curved and was so narrow at times that she had to duck under the water to avoid being hit.*
>
> *"I mustn't drown!" she kept telling herself.*
>
> *Presently the tunnel widened and the roof sloped upward again. Her flashlight revealed a large square niche on one side. It was slightly above water level, and the young detective managed to drag herself up into it. To her delight and relief, the opening was high enough so she could stand up straight.*
>
> *"Thank goodness!" she murmured.*
>
> *Instead of wondering how she was going to get back, Nancy beamed her flashlight around the opening.*
>
> *"What are these?"*
>
> *At the back of the opening was a smaller niche, which formed a sort of shelf.*
>
> *"Something's lying on it!" Nancy thought, excited.*
>
> *A couple of steps brought her to the spot. On it lay a bundle made of tightly woven twigs. Nancy lifted the fagot. It was small, but very heavy.*

Though it's a post-Keene Nancy and we'll discuss computer games in Chapter 27, as any modern Girls Club would play Nancy Drew video games, we'll mention Nancy Drew, The Phantom of Venice. Nancy enters an underground room, dimly lit and lined with rusted pipes, gauges and dials. The door slams behind her and there's rushing sound of water pouring into the room. She's trapped! Has, after all these years, our heroine’s luck finally run out?

Turn some valves, Nancy! And quickly!


Water Flow Chart
Circle Well fills from and drains to Triangle Well.
Triangle Well fills from and drains to Diamond Well.
Diamond Well fills from and drains to Circle Well.

As with the Boys Club serial market, Stratemeyer faced competition.

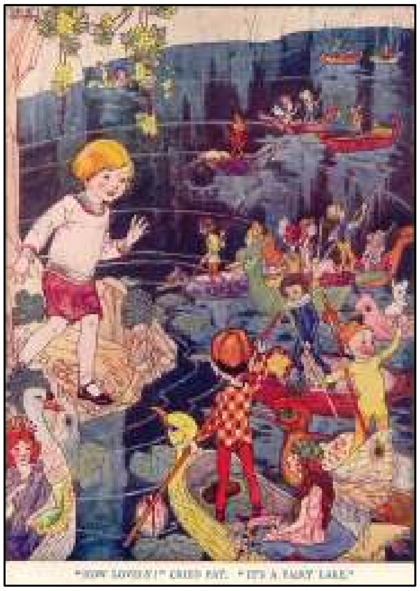

63
Enid Blyton's Mystery Stories

By virtue of output -- 800 books is no small matter --.**Enid Blyton** (1897-1968) was prolific. Blyton's early "The Prisoners of the Dobbadies" in The Enid Blyton Book of Fairies (1924), includes an underground river boat ride as the Dobbadies show their anger at Pamela and Peter's intrusion into their world, but things work out for the better.

The underground boating aspect of the tale is minor in itself, but as we will see, it's the inception of a theme to come.

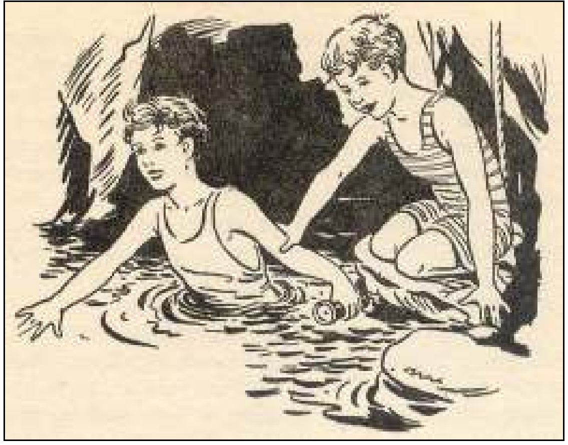
"The Story of Orpheus and Eurydice" in Tales of Ancient Greece (1930), edited by Blyton, tells of "the black River Styx" to the "long, dark passages" of the Underworld.

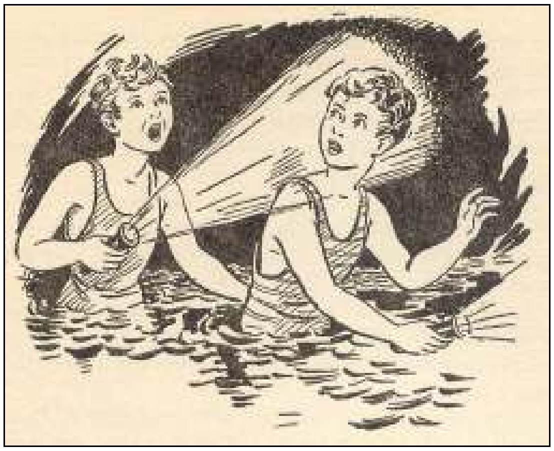
Blyton's literary framework -- as was that most writers of her time -- was steeped in the classics. Charon's river was my no means new territory.



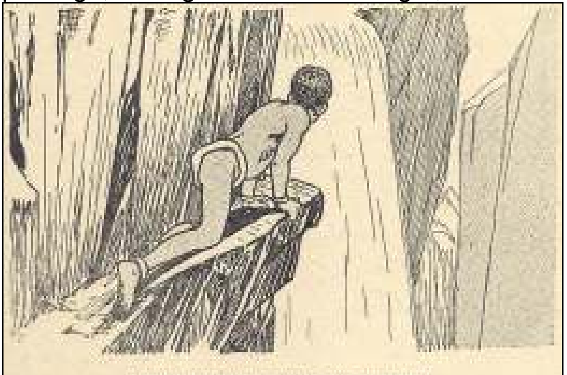
"HOW LOVELY!" CRIED PAT. "IT'S A FAIRY LAKE."

The Children of Kidillin (1940) is set during WW II. Tom and Sheila are sent from London to live with their cousins, Sandy and Jeanie, in Scotland where the boys become curious about stream gushing out of the hillside. Might it be possible to crawl inside and see where it leads? The river within the mountain leads to solution of a mystery!

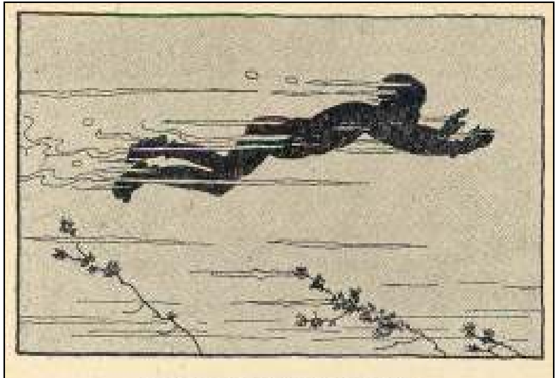




Change the setting to Africa, and the Kidillin underground river isn't unlike the one within The Secret Mountain (1941). That's Mafumu below, who with Jack swims through a water-filled passage, having no idea of its length, twists and turns, constrictions and where it leads.



MAFUMU MADE HIS WAY UP THE MOUNTAIN.



SWAM VIGOROUSLY BELOW THE WATER.

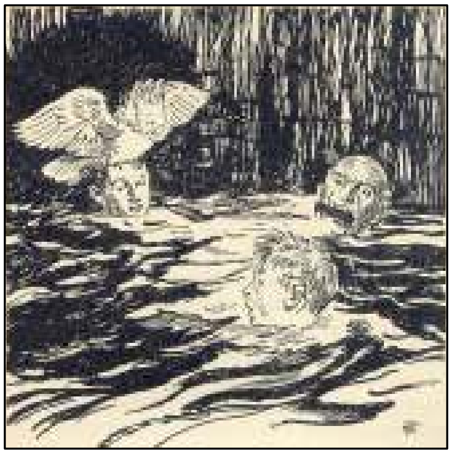
Fortunately for the swimmers, the underground river leads to a chamber which they proceed to explore.

Some 60 years later in a posting to the Enid Blyton Society, Ali from New Zealand (whom we suppose to be female by virtue of her hobby of scrapbooking) reflects on the adventure,

> *I remember in one of the books I read as a child (and the name escapes me at the moment), although it was set in Africa and there was a little African boy that the children befriended, anyway one of the boys was wading through an underground cavern in the mountain and needed to dive down and hold his breath and swim underwater. I think the description said that he was bursting for air by the time he emerged to find air.*
>
> *I found it all very terrifying as a child, imagine if the roof of the cave hadn't lifted and he was in the pitch black with no air. In fact so terrifying that as a child I used to practice holding my breath in the bath just incase I should ever find myself in similar circumstances! (although I don't think I would have risked it.)*

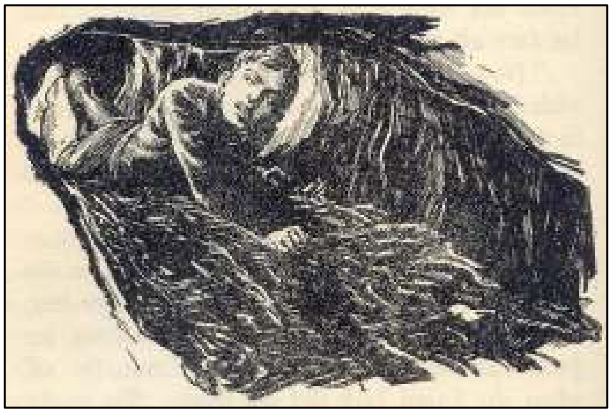
Chapter 37, Achluohydrophobia, is about the fear of underground waters and Chapter 90, Why Do We Believe What We Believe, will suggest that this sort of implant can become a visceral root of belief, but we'll leave it as simply a childhood memory for now. Adventure fiction can stick with us.

The Island of Adventure (1944) has gloomy underground island copper mine that extends from under the sea to a well on the mainland and the bad guys flood the whole system with Bill, Jack and Philip still inside!



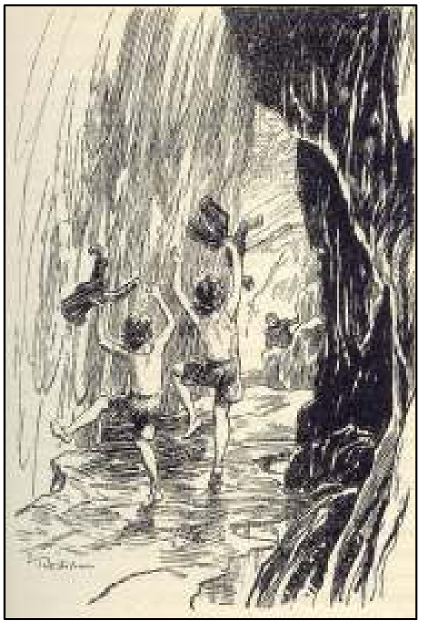
In The Castle of Adventure (1946), Jack enters the Scottish castle via the chilly and claustrophobic underground stream, but the other children fail to notice that he's wet.

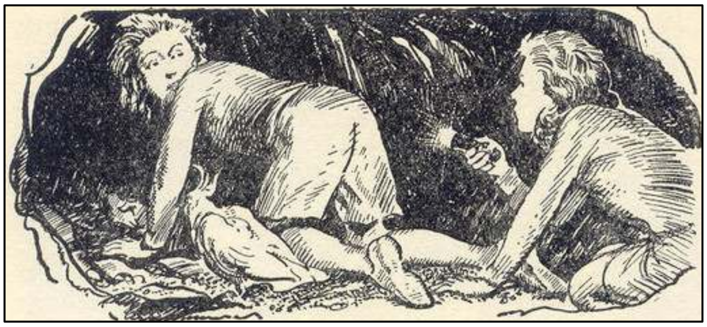
A mystery within a mystery, we can call it.



The African waterfall discovery would be echoed in The Valley of Adventure (1947) set in Austria. Two entrances are discovered into the mountain: a rock that pivots open and the cave from where the river escapes as a waterfall.

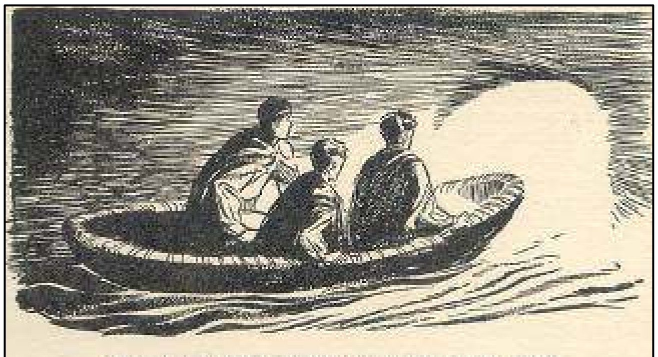
Fortunately Jack, Philip, Dinah and Lucy-Ann have a treasure map.





In The Secret of Killimooin (1943), Peggy, Nora, Jack, Mike, Paul, Ranni and Pilescu see the Secret Forest from their blue and silver plane. There are no passes through the mountains and yet Jack sees smoke rising from the trees.

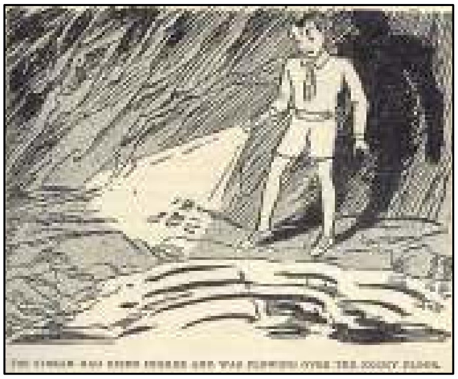
The only way in is via an underground river, which involves evading robbers, and that's as much of the plot as we'll recount.



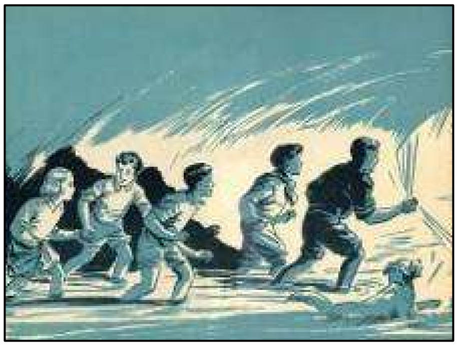
THEY FLOATED RAPIDLY NEARER AND NEARER TO THE GLEAM

> *Jack spoke at last. Ranni, where do you suppose this river goes to? It must go somewhere. If it was penned up in this valley, it would make a simply enormous lake, and it doesn't do that, or we should have seen it from the air, when we flew over.*
>
> *Ranni sat and thought. It must go somewhere, of course, he said. Maybe it finds its way underground, as it did in the mountain. You think perhaps it would be a good idea to follow the*

> *river, Jack, and see if we can float away on it, maybe through a tunnel in one of the mountains, to the other side.*
>
> *We'll go on now, said Ranni. He untied the raft and on they went again, caught by the strong current.*
>
> *Can you hear that noise? said Ranni. I think the river makes a fall somewhere ahead -- maybe a big waterfall. We don t want to be caught in it. I can t get this raft out of the current.*
>
> *Everyone jumped into the water. Paul was the weakest swimmer and big Ranni took him on his back. The raft went bobbing off by itself.*
>
> *Pilescu helped Mike and Jack, but it was a stiff struggle to get to the bank of the swiftly-running river. They sat there, exhausted, hoping that no robber would come by, for they had no strength to resist anyone!*
>
> *They walked on beside the river, over rough ground. The noise became louder and louder. Then they suddenly saw what happened to the mountain river!*
>
> *They rounded a big rock and came to the place where fine flew. The great silver river rushed by them -- and then disappeared completely!*
>
> *So that s what the robber meant when he shouted that we should soon be in the middle of the earth, said Jack. That water must go deep down into enormous holes and crevices among the rocks. I suppose it goes right under the surrounding mountains and comes out somewhere else as a river again. How amazing!*

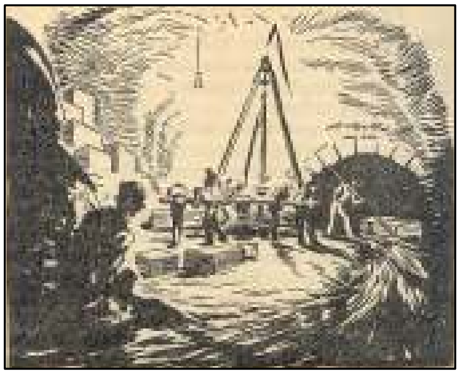


The waterfall entrance idea would be re-used in Blyton's The Adventurous Four Again (1947), now back in England. Tom leaves his camera behind in the recessed cave and clambers through the waterfall hole when the current lessens. He finds a hidden cave full of boxes and inhabited by two men. When discovered, he escapes by dropping into the fast-flowing underground river that sweeps him out to sea, where he is cast onto a rock above where the river and sea met and "fought their eternal battle."



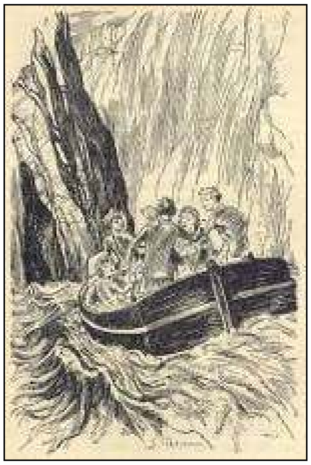
In The Five Go Off in a Caravan (1948), we're never sure where they are, but there's the obligatory secret passage and an enormous cavern in which wading is required.

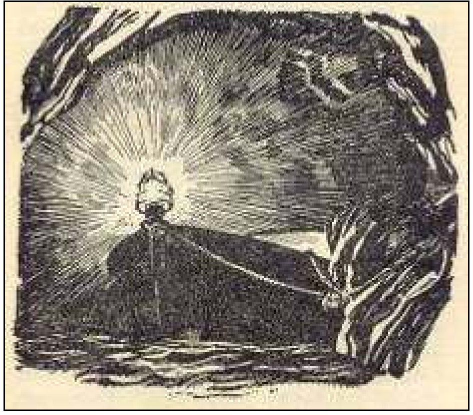
The same elements can be found in the cellar beneath Rockingdown Hall, where in The Rockingdown Mystery (1949), Barney comes across a hole behind a moving stone which leads to an underground stream, "black and gleaming." Men are at work, winching crates of smuggled goods along the channel.

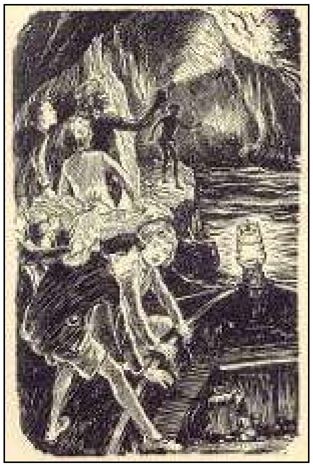


We've had the The Island of Adventure, The Castle of Adventure and The Valley of Adventure. What's left?

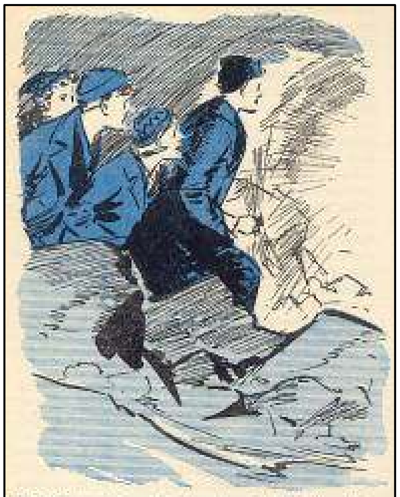
In The River of Adventure (1955), Syria, Jack, Phillip, Dinah and Lucy-Ann sail down the River of Abencha to rescue Bill and Mrs. Cunningham who've been kidnapped by the wicked Raya Uma. The children discuss stalactites and stalagmites. Their indigenous guide saves them from certain death when their craft careens toward a waterfall, but veers underground at the last moment.







In Five Get Into A Fix (1958), the Famous Five are ill during the Holidays and are sent to recover at the Welsh farm of Mrs. Jones and her giant-like son, Morgan. Morgan's suspicious behavior leads the five to a cave and then to an underground river, via which magnetic metal deposits are being shipped.



The children saw the end of it, the exit outlined in brilliant light

Blyton's stories are about secret passages -- passages between castle walls, caves, routes to and from the sea, railway tunnels, the list goes on.

We're awed by the tally of those passages that contain underground rivers, but don't propose that we've found them all.

Again from the postings of the Enid Blyton Society, this time from the member, Sayantani,

> *Has it occurred to all you folks that Enid was quite obsessive about underground streams and rivers? She writes with such intense knowledge about these!*
>
> *I for one am absolutely riveted by these descriptions of hers, especially, I found the climactic scenes in Rockingdown, Castle of Adventure, River of Adventure and Five Go Off on a Caravan fascinating; though Castle does strain the lines of credulity! Rockingdown's denouement of the stream under the house, accessed by a rocky tunnel through a trapdoor from the kitchen gives me goose bumps, as does the stuff in River.*
>
> *Where exactly did she draw inspiration for such topography from?*

The house Enid lived in at as a young woman had an ancient gallery and secret passages, but her fictional settings are clearly more than childhood recollections. A master of engagement, she propels us into flooding caverns that cause us concern, but reliably pop back to light by the final chapter.

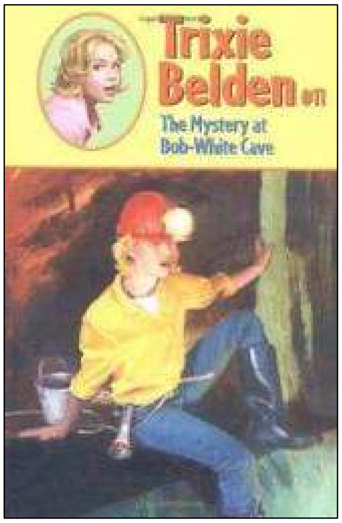
Although her works have been criticized for racism, sexism and snobbery, they continue to find new readers. "She was a child, she thought as a child and she wrote as a child," psychologist Michael Woods summarized the secret of her writing.

We differ with Woods, however, about writing like a child. What kid can write 10,000 words/day?

The Mystery at Bob-White Cave (1962), the Trixie Belden series, 19 volumes between 1948 and 1986, by **Kathryn Kenny**

The kids are off to the Ozarks to spend some time with Uncle Andrew. Trixie can't wait to explore some dark, damp, and most of all, mysterious caves, because she has another scheme up her sleeve. A national magazine is offering a reward to anyone who can find three "ghost cave fish." Nothing will stop Trixie from finding them -- not bats or wild cats or even a real ghost!

We'll learn about such fish in Chapter 47, Wrecks of Ancient Life.



And of course there's **J.K. Rowling**'s Harry Potter, by no means a series aimed particularly at girls, but we'll include it here because females comprise the parger portion of the readership. Harry Potter and the Sorcerer's Stone (1997) being a starting point for those of studying underground waters.

> *They were in a narrow stone passageway lit with flaming torches. It sloped steeply downward and there were little railway tracks on the floor. Griphook whistled and a small cart came hurtling up the tracks toward them. They climbed in -- Hagrid with some difficulty -- and were off.*
>
> *Harry's eyes stung as the cold air rushed past them, but he kept them wide open. Once, he thought he saw a burst of fire at the end of a passage and twisted around to see if it was a dragon, but too late -- they plunged even deeper, passing an underground lake where huge stalactites and stalagmites grew from the ceiling and floor. "I never know," Harry called to Hagrid over the noise of the cart, "what's the difference between a stalagmite and a stalactite?"*
>
> *"Stalagmite's got an 'm' in it," said Hagrid. "An' don' ask me questions just now, I think I'm gonna be sick."*

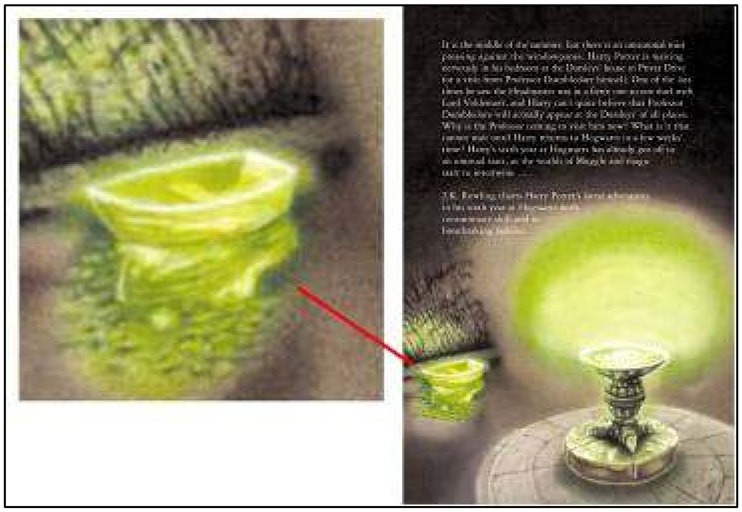
Harry Potter and the Half-Blood Prince (2005) is darker. Professor Dumbledore apparates himself and Harry to a seaside cliff where his wand illuminates a fissure, but fails to open opening a passageway. Divining its secret, Dumbledore cuts his arm, saying that Voldemort wishes those seeking his artifacts to be weakened.

> *The blood-spattered rock within it simply vanished, leaving an opening into what seemed total darkness. "After me, I think," said Dumbledore, and he walked through the archway with Harry on his heels, lighting his own wand hastily as he went.*
>
> *An eerie sight met their eyes. They were standing on the edge of a great black lake, so vast that Harry could not make out the distant banks, in a cavern so high that the ceiling too was out of sight. A misty greenish light shone far away in what looked like the middle of the lake; it was reflected in the completely still water below. The greenish glow and the light from the two wands were the only things that broke the otherwise velvety blackness, though their rays did not penetrate as far as Harry would have expected. The darkness was somehow denser than normal darkness.*

Fans weren't at a loss for discussion topics. Take, for example, the Bloomsbury U.K. edition's back cover where behind the Pensieve is a boat with a cavernous wall in the background.

What could this boat mean?

MuggleNet.com, the site for ardent Potter scholars, has more than 40 "Underground Lake" editorials.



And there will be the spinoffs. Harry Potter's World of Magic Theme Park -- not to be confused with Universal Studios' Wizarding World of Harry Potter, Orlando -- exists only in cyberspace. To play, one needs:

1, Imagination, as was demanded by the books.
2. A credit card.

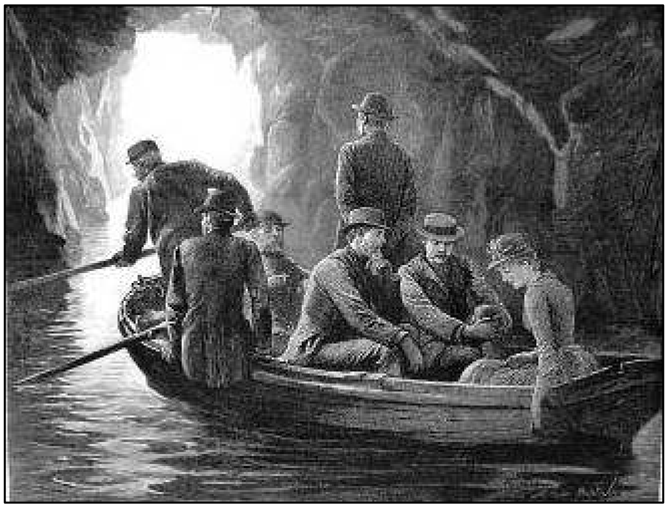
Nestled in a hidden valley that repels Muggle intruders lies Godric's Hollow where one must boat-ride through a cave in search of the sorcerer's stone.

Girls Club Singles

While our list of non-series underground river books written for girls isn't as lengthy as the list for boys, it's indeed as varied.

"First Person Singular," by **David C. Murray** in the August 29, 1885, Graphic was by far too romantic for a Boys Club, but Victorian girls would have enjoyed picturing themselves in the craft to the right.

> *To exit from the caves is made by water, and the slow moving oars bumped the boat little by little towards daylight.*



Mary E Bradley's Mizora, A Prophecy, A Mss. Found among the Private Papers of the Princess Vera Zarovitch (1889) is about an enlightened female society existing underground in perfect harmony, blessed with technologies permitting leisure for continuous education, genetic manipulation of crops and the manufacture of pure foodstuffs. But best of all, males are no longer biologically required. To enter Mizora, go to the North Pole and downward.

From the Princess' private papers,

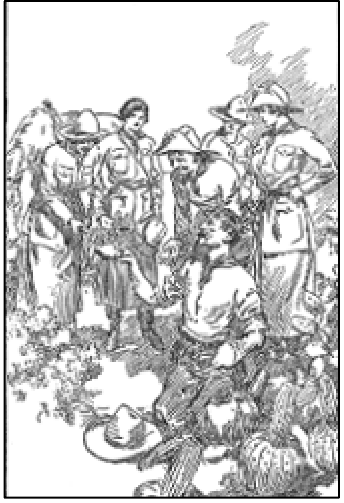
> *I entered a broad river, whose current was from the sea, and let myself drift along its banks in bewildered delight.*

While the Mizoran river has little literary uniqueness, its utilization by electrolysis is novel.

> *They separated water into its two gases, and then, with their ingenious chemical skill, converted it into an economical fuel.*
>
> *There were several processes for decomposing the water explained to me, but the one preferred, and almost universally used by the people of Mizora, was electricity. The gases formed at the opposite poles of the electrical current, were received in large glass reservoirs, especially constructed for them.*
>
> *I must not forget to give some notice to their water supply in large cities. Owing to their cleanly advantages, the filtering and storing of rain-water in glass-lined cisterns supplied many family uses. But drinking water was brought to their large cities in a form that did not greatly differ from those I was already familiar with, excepting in cleanliness. Their reservoirs were dug in the ground and lined with glass, and a perfectly fitting cover placed on the top. They were constructed so that the water that passed through the glass feed pipes to the city should have a uniform temperature, that of ordinary spring water. The water in the covered reservoirs was always filtered and tested before passing into the distributing pipes.*

It's a high-tech waterworks, to be sure, given that the manuscript's more than a century old.

Grace Harlowe's Overland Riders on the Great American Desert (1921) by **Jessie Graham Flower** followed the Boys Club story line, even down to the hats. (See The Border Boys Across the Frontier illustration in Chapter 20.)

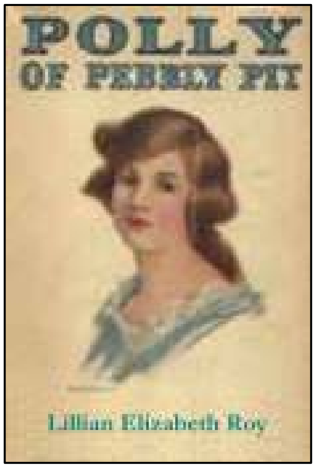


In selecting mounts for their desert journey, Grace Harlowe selects an "outlaw" pony. "Don't reckon you'll be able to stick on him," warns Hi Lang, the guide. Grace flings herself into the saddle and off they go!

> *Early in the afternoon the guide began looking for water, now and then dismounting to search about for a tank, breaking in crusts of alkali, putting an ear to the ground to listen for the murmur of an underground stream, or feeling with his hands over several yards of hot sand in search of a cool spot that might indicate water.*

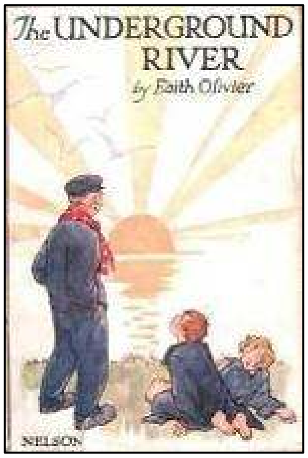
Polly of Pebbly Pit (1922) by **Lillian Elizabeth Roy** surely sounds like a girls' story and indeed it is.

> *"Well, look out in front; there's a ledge cleft in the side of the mountain wall. Between it and the other lower ledge is a canyon that might be the one Montresor found on his up-climb. Yonder the slope meets the chasm and above is the steep sides leading to Top Notch Trail. Could not the land-slide have buried this wall and then a great wash-out have cleared it again? If we only had a gushing mountain stream pouring from the cliff-side the setting would be complete!"*
>
> *Barbara gasped, but Polly clapped her hands. "Nolla, that's it! The subterranean stream we found in there. Some big upheaval changed its outlet, or maybe this gold vein runs clean through and Montresor's claim is staked opposite this side -- just where the river pours out. We must look over that side to-morrow."*

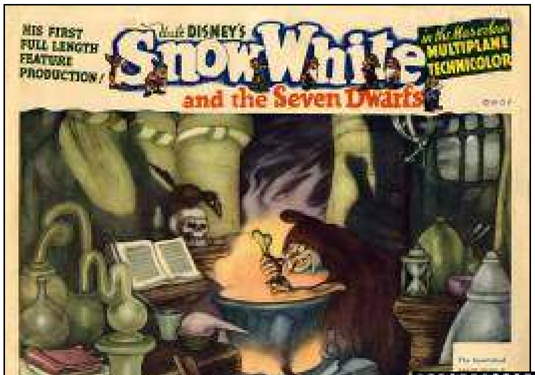

POLLY
OF PEBBLY PIT
Lillian Elizabeth Roy

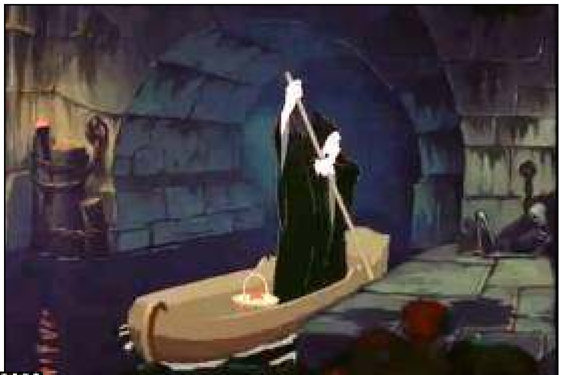
Edith Olivier's first novel, The Love-Child (1927), a story of a neurotic, possessive spinster haunted by an imaginary child, was one of the genre of fantasy novels popular in the early 20th century. Most of Olivier's works drew on her affluent background and showed a curious interest in split personalities. Olivier is parhaps better known, however, for being a confidante and hostess in the her day's aesthetic, upper-class homosexual circles.

Scarcely noted in her biographies is her effort in children's literature, The Underground River (1928). She's labeled today as a feminist pioneer of unrealized literary potential.


The UNDERGROUND RIVER
by Edith Olivier
NELSON

Walt Disney's Snow White and the Seven Dwarfs (1937) is a film classic, the first full-length animated color feature with sound


HIS FIRST FULL LENGTH FEATURE PRODUCTION!
Walt DISNEY'S
Snow White
and the Seven Dwarfs
in the Marvelous MULTIPLANE TECHNICOLOR



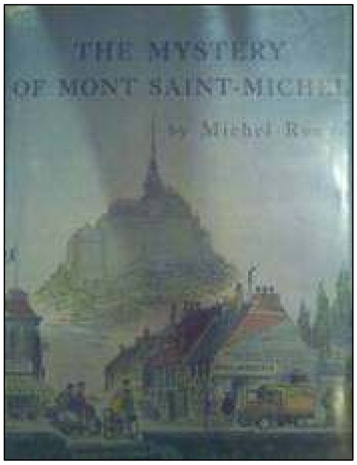
Whittier Theatre
ORCHESTRA
APR. 27
WED'N'DAY MAT
W
1938
$1.10
Walt Disney's
SNOW WHITE
and the Seven Dwarfs

Disguised as a stooped hag, the wicked queen poisons an apple by dipping it into a boiling caldron. Charon-like, she pushes off in her canoe down a subterranean waterway to deliver the slowing fruit to Snow White.

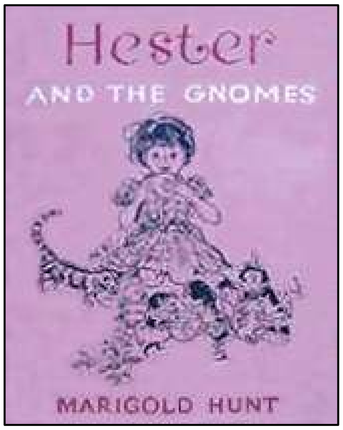
Henrietta's House
Elizabeth Goudge
UNIVERSITY OF LONDON PRESS LTD
HODDER AND STOUGHTON LTD

In Henrietta's House (1942) by **Elizabeth Goudge**, Henrietta and her brother Hugh John go for a picnic where they encounter a sinister gatekeeper and an elderly gentleman who builds bowers in the forest for imagined Sleeping Beauties and a mysterious house fitted up just as Henrietta had dreamed. Hugh John finds an underground river and a boat and thus discovers a robbers' den.

Given the helter-skelter plot, the reviews were surprisingly high-brow and positive, but as an underground river saga, it's probably not a keeper.



In The Mystery of Mont Saint-Michel (1955) by **Michel Rouze**, four French boys and one girl decide to explore the famous Mont Saint-Michel Abby, but are soon lost in a network of passages and caves. They avoid the rising water, provide themselves with light, fire and food and investigate in the legend that here once grew the great Forest of Cokelunde. Not an underground river, exactly, but underground tides.



In Hester and the Gnomes by **Marigold Hunt** (1955), when Hester's father drilled a well on his farm, he pierced the roof of the gnomes' underground river and the little fellows decided to journey to the upper world to set things straight.

In The Cave of Cornelius (1959), retitled The End of the Tunnel (1969) by **Paul Capon**, four children searching for lost Roman treasure stumble into a secret world beneath the earth which is inhabited by descendants of the very Romans whose treasure they have been seeking. These people, with their debased Latin and partly-archaic, partly-modern appurtenances, guard their secret and their habitat rigorously. Fortunately the children make contact with a contemporary who has long been held prisoner and all escape by a subterranean river route which eventually brings them out in Paris, via the catacombs.

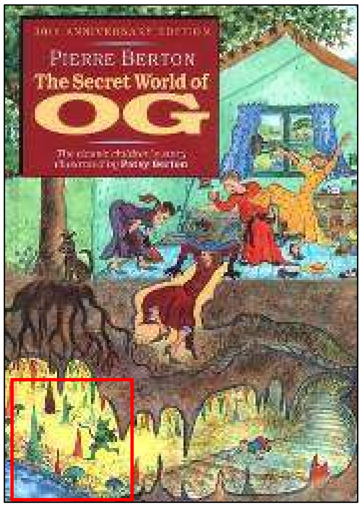
The Secret World of Og (1961) by **Pierre Berton** is about four siblings,

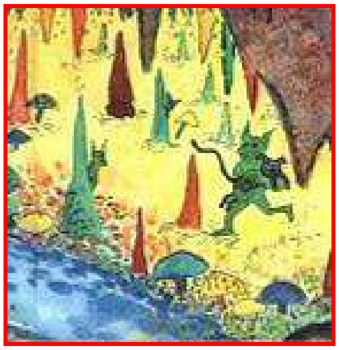
Penny, the leader,
Pamela, her common-sense sister;
Peter, whose life's ambition is to become a garbageman, and
Patsy, who collects frogs in her pockets

who set out in search of their baby brother,

Paul, better known as "The Pollywog"

who has vanished mysteriously from their playhouse. Accompanied by their fearless pets, the children descend through a secret trapdoor into a strange underground world of mushrooms, whose green inhabitants know but one word, "OG!"

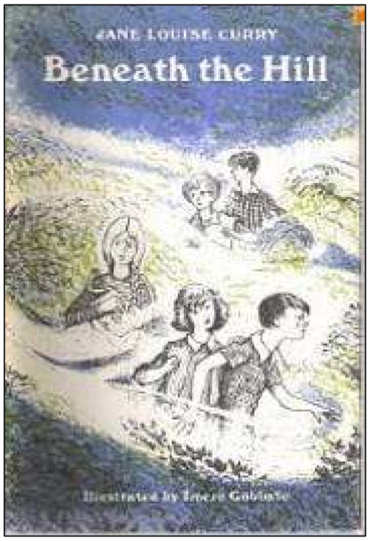




Detail of the Ogian river from the 50th anniversary edition

In Beneath the Hill (1967) **Jane Louise Curry**, modern children met a boy from a Welsh/Irish fairy clan who've dwelt in America for centuries. When developers to bulldoze the landscape, the magical folk release an underground river to wash away the modern bane.

> *The company then retraced their steps, returning through the passage to the forking of the ways, where the lamplit stair climbed downward. A faint trembling beneath their feet told them that the river flowed below through a channel or some fissure in the rock. Its destination was the same as theirs -- the long galleries below -- and near where the stairway ended, it issued forth to flow beneath low banks through the series of dark chambers ahead.*



> *Five or six of the Fair Folk waited for them at the water's edge. Two were kindling pine-knot flares, which had been flattened to flat disks of wood. Another held by a tether an odd round shell of a boat that Durwen promptly entered.*

> *The others, except the three who had in charge the lamps and the boat, followed. Miggle did so most reluctantly, for every time she reached her foot out, the gap of dark water between the bank and low-riding boat grew larger. Not until the second rope had secured it, steadying it fast against the bank, did she succeed in climbing in.*

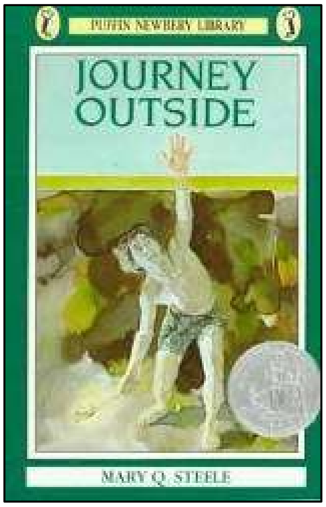
> *At once those left on shore set the wooden lamps afloat and freed the boat. Slowly, the wide and shallow scallop moved out into the swifter center of the stream, and there, set amid a flotilla of lights, it moved down the darkness.*

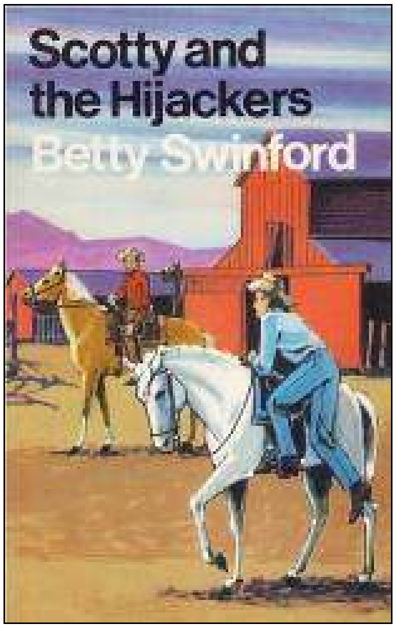
"We seldom come below the level of the Great Hall," Durwen said, speaking over his shoulder. "These chambers have no passage but by water. They are cheerless and seem to have been roughly used, perhaps as storerooms..."

Maelin nodded. "There is an unhappy feeling here. At lease it seems so to me. Through the water be sweet and the air clear, here -- even as below -- I sense the weight of the mountain pressing on my heart."

Mary Q. Steele's Journey Outside (1969) is about a boy, but it's not Boys Clubish. The Raft People live in darkness and travel a circular journey on an underground river. One boy finds his way outside and tries to learn as much as possible so he can ultimately lead his people to the Better Place.

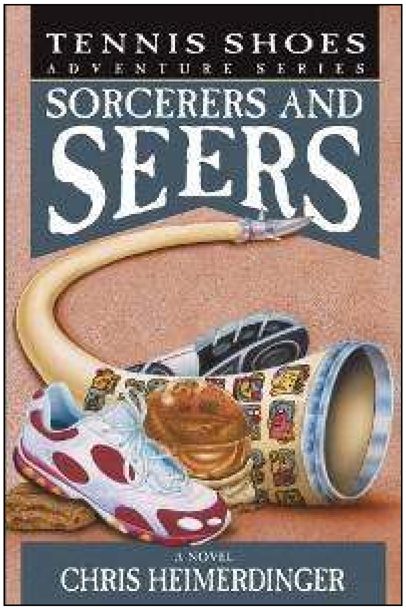
What makes this story unique is the inside-out perspective. The inner world is the reader's world. The shadowed raft is the reader's home, the place he or she feels safe. In the best of Greek structure, it's a quest. A 1970 Newbery Honor book, this one's well written.


PUFFIN NEWBERY LIBRARY
JOURNEY OUTSIDE
MARY Q. STEELE


Scotty and the Hijackers
Betty Swinford

Scotty And The Hijackers (1971) by **Betty Swinford** adds a Christian slant. An energetic preteen gallops into western adventure. A wrecked plane, an underground river -- these and other stirring encounters teach Scotty to ride with God.

Though Scotty is indeed a boy, this one isn't a Boys Club saga -- though Scotty's buddies might benefit by reading it.


TENNIS SHOES
ADVENTURE SERIES
SORCERERS AND
SEERS
A NOVEL
CHRIS HEIMERDINGER

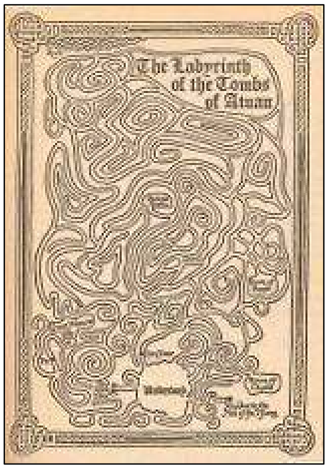
Sorcerers and Seers (2010), a Tennis Shoes Adventure by **Chris Heimerdinger**, is for Mormon girls and boys. A group of teens go spelunking in Frost Cave, and after falling into an underground river they find themselves in the land of the Nephites.

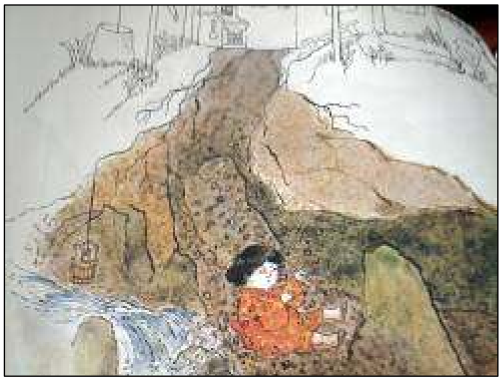
That it's the land of the Nephites would be important to Mormans, as we'll learn in Chapter 86, The Rio San Buenaventura.

The Tombs of Atuan (1972) by **Ursula LeGuin** is about Tenar, a girl taken from her home by the Nameless Ones to be the Priestess Ever Reborn. At 15, she first enters the tomb beneath the Throne to learn the paths within the Labyrinth.

> *The spiderweb of stone-walled tunnels underlay all the Place and even beyond its walls; there were miles of tunnels, down there in the dark.*

While exploring the Labyrinth, she is startled to meet the young wizard Ged who is sear5ching for the broken ring of Erreth-Akbe. She first takes him prisoner and then hides him until the Nameless Ones become angry. In the upper left corner of the map is the river by which the two make their escape in Ged's boat as the Labyrinth collapses in an earthquake.





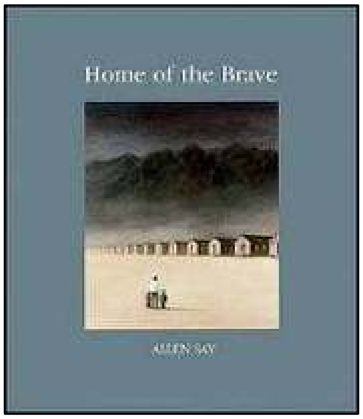
The Funny Little Woman (1973 Cadlicott winner) by **Arlene Mosel** takes place in an underground world occupied by the ferocious Onis who made the funny little women cook for them. When she tried to escape via the underground river, the Onis swallowed all the water and she was stuck in mud. When they began to laugh, however, they spit out the water and she made her way home where she became the richest person in Japan.

In the same series, the opportunistic barbarian Malak, who is not above lying, stealing, threatening or bullying, has the ability to divert an underground river into the Sleestak egg caves if they don't pay tribute.

In Escape into Daylight (1976) by **Geoffrey Household**, Carrie and Mike are kidnapped and imprisoned beneath a ruined abbey. The only escape is via twisted passages and of course an underground river.

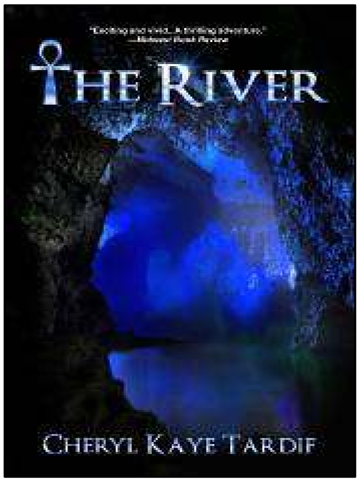
Home of the Brave (2002) by **Allen Say** is aimed at grades 5 to 8. From its synopsis,

> *This picture book for older readers starts as a classic time-travel adventure: a young man hurtles down the rapids in a kayak, is swept into an underground river, and emerges to find himself in the desert, near what he thinks is a ruined Indian reservation. He meets children with name tags, Japanese Americans like himself, who live in an internment camp, and he finds his own name tag there. "Take us home!" the children cry, but thundering voices and blinding lights shoot from the watchtower.*

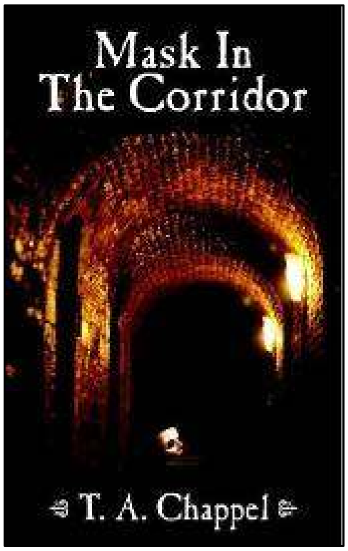


Here's a synopsis of **Cheryl Kaye Tardif**'s, The River (2005). Seven years past, Professor of Anthropology Del Hawthorne's father and three of her friends disappeared near Canada's Nahanni River. When one of the missing stumbles onto the university grounds, alive but barely recognizable and aging before her eyes, Del is shocked, and even more so when the man rambles about a secret river and time travel. Then he tells her that her father is still alive!

Del travels to the Nahanni were she finds a secret channel that plunges into a subterranean technologically-advanced world of nanobots and uncovers a conspiracy that threatens us all. Will humanity be sacrificed for the taste of eternal life?



And then there's Mask in the Corridor (2006) by **T.A. Chappel**.



> *The wooden floor creaked under her. There were a few loose boards and she could hear the sound of fast-moving water beneath her. Rapids? The underground river? she wondered. Suddenly, the floor below her split open and Jillian fell through screaming. She landed, scared stiff, on a suspended rope bridge, which was rotted in some places. She held on for dear life and looked down in horror at the swiftly moving dark river, illuminated by her halogen lamp. Petrified, her knuckles white from gripping the rope, she looked around the cave and could faintly see an outline of daylight streaming into the cave, farther down the river... Jillian looked ahead to see where the bridge led to, maybe she could crawl to the other side, but all she saw was just another dark tunnel and the rope bridge didn't look very safe... Suddenly, she felt it move under her and got a better grip of it just in time as the rotted remains of the bridge broke. She found herself swinging on a very thin cord forty feet above a swiftly moving river.*

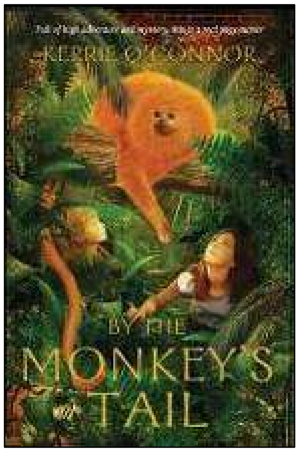
The Boys Club may now be the Boys and Girls Club, but bad writing is still bad writing.

The Magic Medallion (2006) by **Mary Cunningham** is a time travel adventure in which Cynthia and Gus are swept into an underground river while searching a Southern Indiana cave for a lost medallion. An excerpt:

> *I went flailing into the water the split second Cynthia reached out to grab me. I couldn't see what happened to her, but the scream I heard and the following splash said it all.*
>
> *The current seemed to be moving faster and faster. I tried unsuccessfully to grab onto the rough ledge, but instead, I floated deeper and deeper into the cave.*
>
> *I helplessly tumbled over and over in the blackness and thought about the irony of the swimming trophies and scout badges I'd collected over the past three summers. Hmmmphh. A lot of good that did me!*
>
> *With every breath, I gulped more and more water. A feeling that I probably wasn't going to get out of this alive swept over me, and at the same time I wondered if Cynthia was faring any better. For some reason, it was comforting to know that she was probably going to drown with me...*

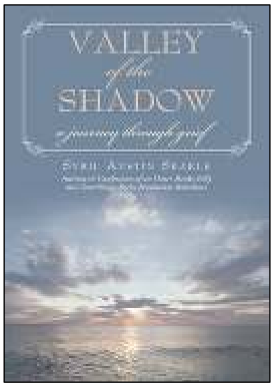
> *Yep, I'm dying all right…there's the bright light I've heard about. I was being pulled straight toward a small glow in the distance as a feeling of peace began to take over. That peace didn't last long, though, as my ears picked up the deafening roar of a huge waterfall…a real one this time! I started paddling backwards as fast as possible but couldn't fight the current and started falling and falling and falling. Moments after I heard screams telling me that Cynthia was falling too, I landed face down in the water. Gathering the strength to look up, I couldn't believe my eyes. We were in a river outside the cave.*

In By the Monkey's Tail (2006) by **Kerrie O'Connor**, Lucy, Ricardo and their Telarian friends outwit the soldiers oppressing civilians in the world of Telares. The young protagonists battle an underground river, take part in a desperate chase and attempt a daring rescue.



The Young City, The Unwritten Books (2008) by **James Bow** addresses that perplexing question, what happens when the future becomes the past? Rosemary and Peter fall into an underground river and are swept back in time, to Toronto in 1884. As the days turn to weeks, then months, they begin to wonder, what if they can never return? Then someone brings them a watch powered by a battery made in Taiwan!

Valley of the Shadow: A Journey through Grief (2009) by **Sybil Austin** Skakle has a romantic theme, something no Boys Club would allow.



> *The receding water's strong vortex sucked Cody backwards down the hole in the middle of the pond. One hand wavered above the water for a moment and then vanished.*
>
> *Otho walked back to the camel and got a length of rope. He called Norm over to his side. Before Norm knew what was happening, Otho had tied the rope around his waist.*
>
> *Orho looked down at him and said in his sternest voice, "Walk down to the edge of the hole and see if you can spot Cody."*
>
> *Norm slowly trudged forward. Slowly he waded through the mud until he reached the opening and cautiously looked down the hole. He yelled back over his shoulder, "It drops about thirty feet to a subterranean river which flows rapidly to the east, but there is no sign of Cody."*
>
> *Norm yelled, "Cody," a couple of times but there was no answer. He looked at the others and said, "He must have been washed away by the underground river. It looks fast."*
>
> *Kristi's brown eyes were desolate... She started crying, "I never even told him that I loved him!"*
>
> *Otho went over, put his arm around her, and said," Done worry, he'll be all right. You watch and see he's a survivor. He'll show up somewhere, somehow."*
>
> *Nevertheless, in his heart, Otho had his doubts.*
>
> *Even if he survived a thirty-foot fall, could he survive a turbulent underground river?*

Final Thoughts

It's been a free-wheeling, these chapters of juvenile literature review. Some of the works have been well crafted and some have been taxing, but all draw us into spaces where only the author knows the exit.

Before we exit the library, however, we can make a brief pass through the passages we've quoted in our several chapters on fiction. While our sample is not random, of course, a word count reveals something of the impressions the authors wished to convey. Here are a few comparisons:

Words signifying darkness e.g., dim, shade	:	Words signifying brightness e.g., brilliance, sparkle	2:3
Words signifying largeness e.g., great, ceaseless	:	Words signifying smallness e.g., small, tiny	2:1
Words signifying quickness e.g., rapid, sudden	:	Words signifying slowness e.g., slow, sluggish	4:1
Words suggesting negativity e.g., monstrous, dread	:	Words suggesting positivity e.g., fantastic, splendid	3:2

The quintessential tale: the adventurer embarks on an illuminated underground river, sees awesome sights and rushes onward, barely escaping misfortune.

Here are a few of the fictional rivers' common attributes.

Unlike a river on the terrestrial surface, underground waters have a roof of stone arching above. While the closed spatial dimension shouldn't affect any adventurers but those in aircraft -- which indeed we have noted -- the roof remains a barrier to freedom. A voyager on an underground river is to some degree a captive.

As a current is prone to do to do, these rivers propel the characters onward. More commonly than not, the voyager is drawn into a sequence of increasing adventure. The option to turn back is lost and what's ahead isn't foretold,

Homer's River Pyriphlegethon was of fire and Dante's River Phlegethon was of blood. The rivers of more-recent writers, however, are of -- well -- just water. Familiarity helps us board the boat, so to speak. From our upper-world experiences, we know how a craft rocks as we shift our weight, how it spins as it shoots the rapids, how it may capsize where the channel is deepest. It's real.

For similar reasons, the underground oceans of fiction are reasonably free of sea monsters and the like, objects of danger which might enliven a normal adventure under the upper stars. A protagonist entering into the earth to face but the nemeses above ground isn't much of a yarn.

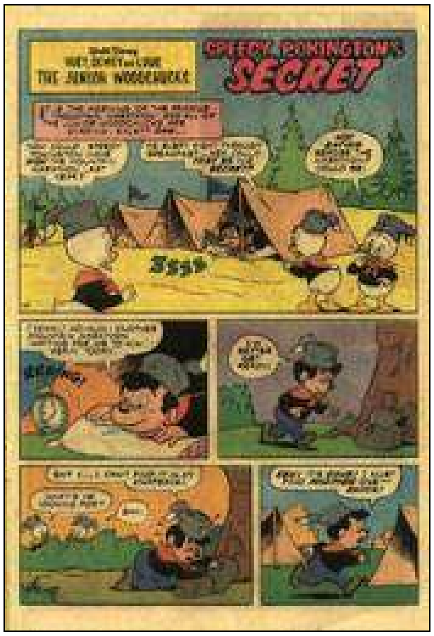
CHAPTER 24

UNDERGROUND RIVERS IN THE COMICS

And what Boys Club doesn't read comic books?

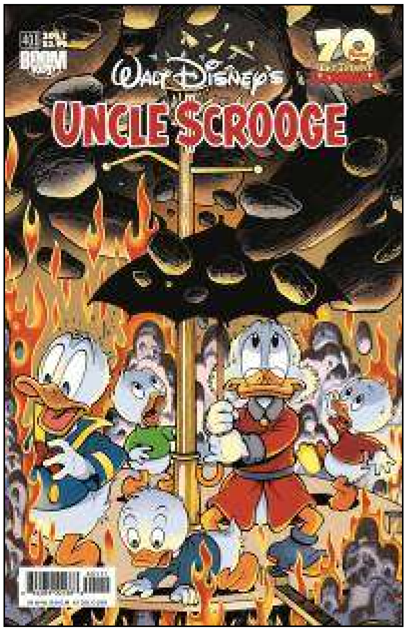
We'll begin with some familiar anthromorphized critters.

We might anticipate that Mickey Mouse would be involved in subterranean escapades, but the more adventurous of the extended duck family are Uncle Scrooge and the nephews Huey, Dewey and Louie.



"Speedy Pokington's Secret"
Junior Woodchucks, July 1975

A savvy Woodchuck uses a subterranean river to win the mountain marathon.

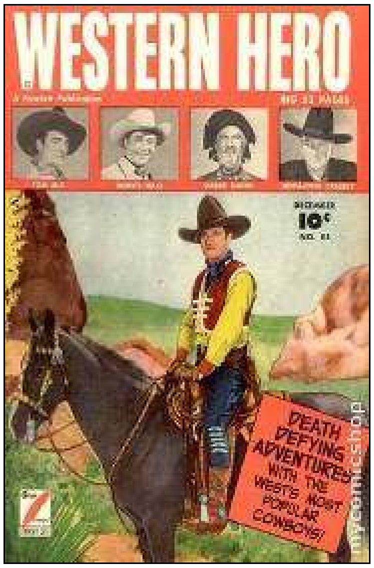


"The Universal Solvent"
Uncle Scrooge # 401, 2011

Scrooge McDuck finds a way to bore to the planet's core using a solvent that condenses everything but diamonds. After the boys explain the potentially catastrophic impact of this act -- it will cause the globe's destruction -- all go down the shaft to retrieve the chemical.

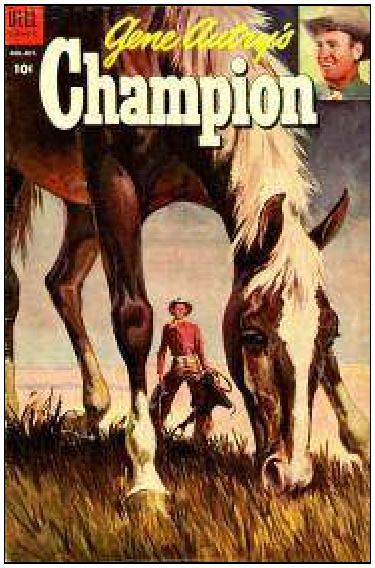
Cowboys

We'll look at several comic book cowboys, most of them also being Western movie idols. Underground rivers play a role in cowboy yarns, but not the campfire variety.


WESTERN HERO
10¢
DEATH DEFYING ADVENTURES WITH THE WEST'S MOST POPULAR COWBOYS!
mycomicshop

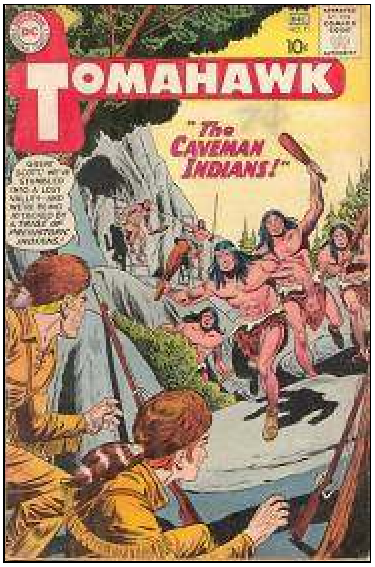
"The Underground River"
Western Hero # 85
December 1949

The first cover is Tom Mix, star of more than 300 films between 1910 and 1935, all but nine of which were silent features. As he died in 1940, his underground river saga was posthumous.


DELL
10¢
Gene Autry's
Champion

Champion
Comic Series, 1951-1959
Television Series, 1955-1956

Champion was Gene Autrey's horse, but he didn't need the singing cowboy for his own comic. In "Lost River," episode 5 television version, an underground river can save Champion's herd from a fatal drought -- but only if he can find it.

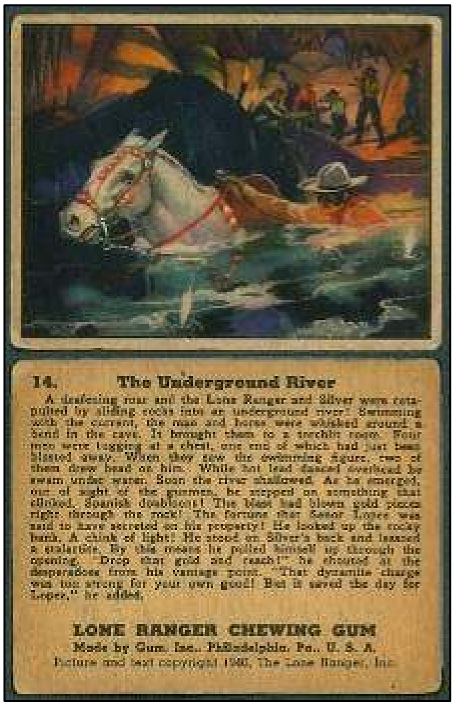

DC
10¢
TOMAHAWK
"The CAVEMAN INDIANS!"

"The Caveman Indians"
Tomahawk # 71
November 1960

While exploring for new hunting grounds Tomahawk, a cowboy-type of Revolutionary War times, and young Dan are caught in a landslide and fall into an underground river. After making it ashore, they are captured by Caveman warriors. Can they escape?

Lone Ranger Chewing Gum allowed a trading-card sized underground river adventure. We'll retype the 1949 saga, as the card's a bit hard to read.

> *A deafening roar and the Lone Ranger and Silver were catapulted by sliding rocks into an underground river! Swimming with the current, the man and horse were whisked around a bend in the cave. It brought them into a tourchlit room. Four men were tugging at a chest, one of which had just been blasted away. When they saw the swimming figure, two of them drew a bead on him. While hot lead danced overhead, he seam underwater. Soon, the river shallowed. As he emerged, our of sight of the gunmen, he stepped on something that clinked. Spanish doubloons! The blast had blown gold pieced right through the rock! The forturen that Senor Lopez was said to have secreted on his property! He looked at the rocky bank. A chink of light! He stood on Silver's back and lassoed a stalactite. By this means he pulled himself up through the opening. "Drop the gold and reach!" he shouted at the desperadoes from his vantage point. "That dynamite charge was too strong for your own good! But it saved the day for Lopez," he added.*



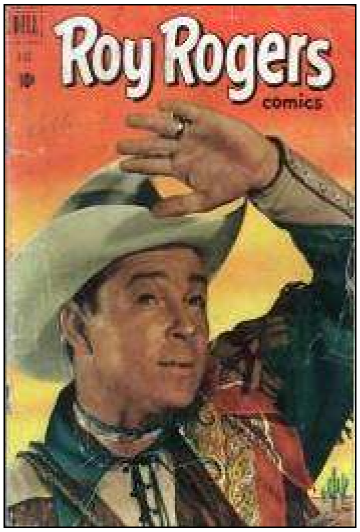
14. The Underground River

LONE RANGER CHEWING GUM

Made by Gum, Inc., Philadelphia, Pa., U. S. A.

Picture and text copyright 1940, The Lone Ranger, Inc.

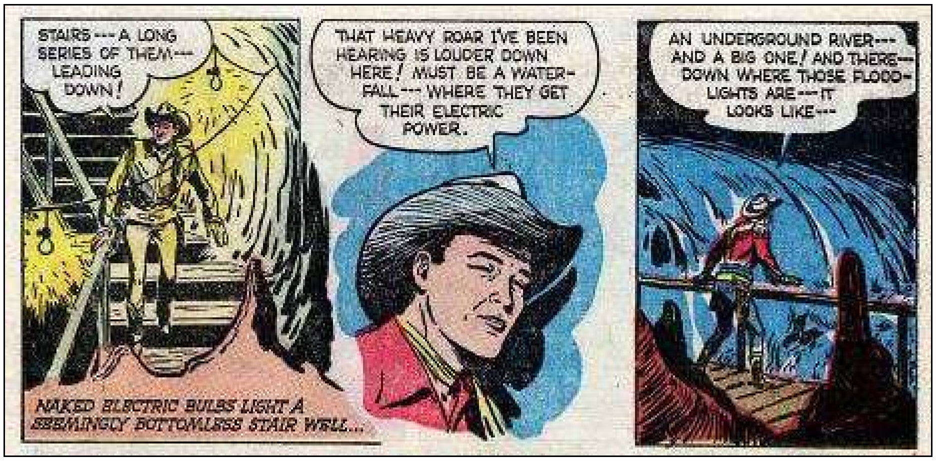
And no cowboy list would be complete without the King of the Cowboys, Roy Rogers. We'll limit ourselves to just one of his comic book adventures, "River of Gold," in which Roy helps the FBI

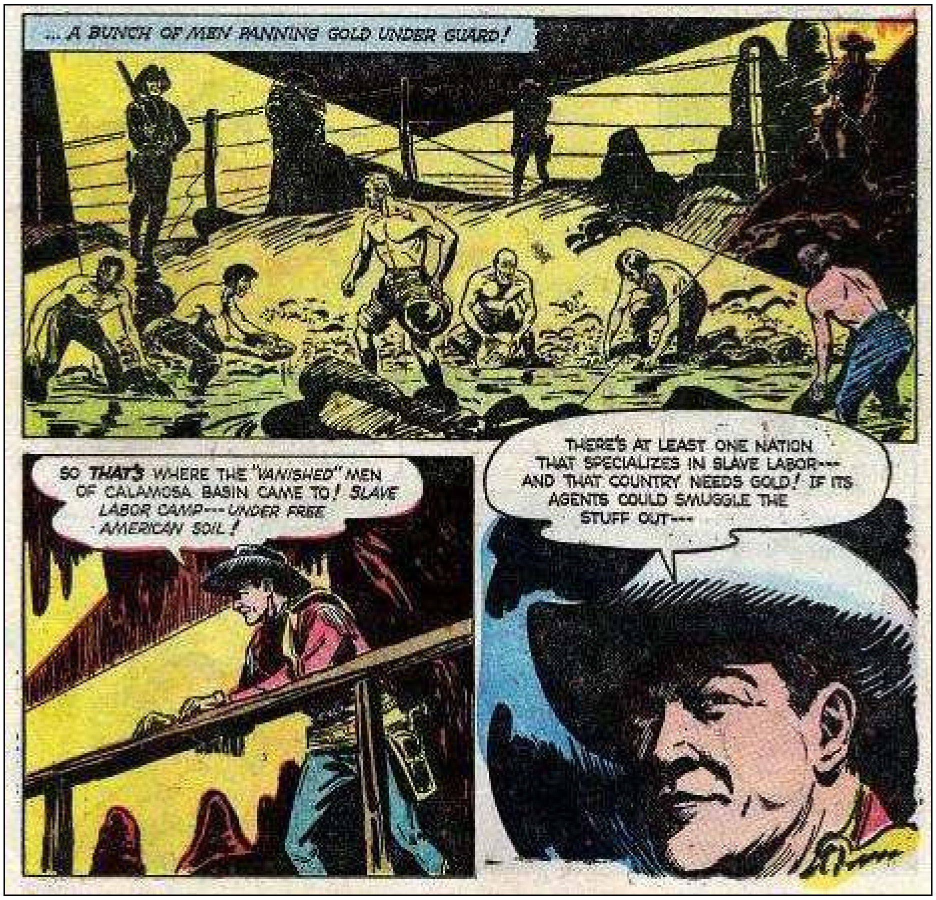


"River of Gold"
Roy Rogers Comics # 48
December 1951

The front cover, Roy looking into the sun. The back cover, on the other hand, shows Boys Clubs what a cowboy rides, other than his horse.

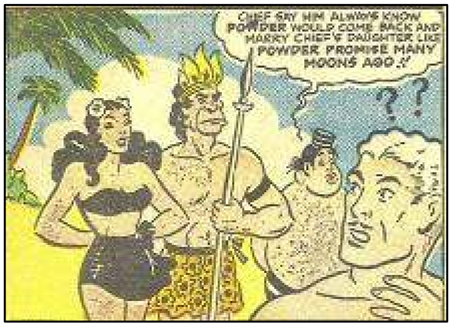
As for where the River of Adventure takes Roy, we can read the source material.


STAIRS --- A LONG SERIES OF THEM --- LEADING DOWN!
NAKED ELECTRIC BULBS LIGHT A SEEMINGLY BOTTOMLESS STAIR WELL...
THAT HEAVY ROAR I'VE BEEN HEARING IS LOUDER DOWN HERE! MUST BE A WATERFALL --- WHERE THEY GET THEIR ELECTRIC POWER.
AN UNDERGROUND RIVER --- AND A BIG ONE! AND THERE --- DOWN WHERE THOSE FLOODLIGHTS ARE --- IT LOOKS LIKE ---


... A BUNCH OF MEN PANNING GOLD UNDER GUARD!
SO THAT'S WHERE THE "VANISHED" MEN OF CALAMOSA BASIN CAME TO! SLAVE LABOR CAMP --- UNDER FREE AMERICAN SOIL!
THERE'S AT LEAST ONE NATION THAT SPECIALIZES IN SLAVE LABOR --- AND THAT COUNTRY NEEDS GOLD! IF ITS AGENTS COULD SMUGGLE THE STUFF OUT ---

Boys Clubs, too, help defeat Communism.

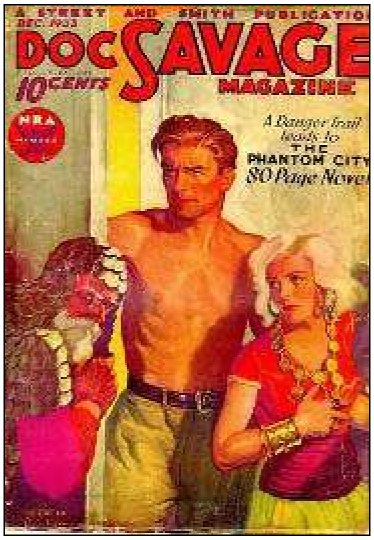
But underground rivers aren't all beneath the range and there are heroes other than those with six-shooters.


CHIEF SAY HIM ALWAYS KNOW POWDER WOULD COME BACK AND MARRY CHIEF'S DAUGHTER LIKE POWDER PROMISE MANY MOONS AGO!!
??

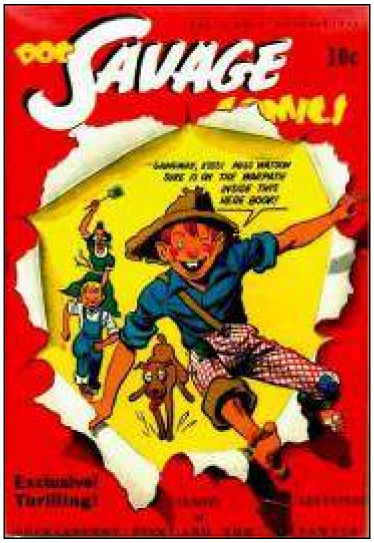
Heroes

Even aerial ace Smilin' Jack (2:14, January 1942) can't avoid underground rivers when he flies into a storm causes his ship to crash on an island where the native savages mistake him for Powder, who it seems has visited before and agreed to marry the Chief's daughter. Despite his protests, Jack is engaged, but at the final step of the wedding ceremony -- a drink from Mystery River -- Jack sees that the stream flows from a cave, dives in and escapes to the ocean.

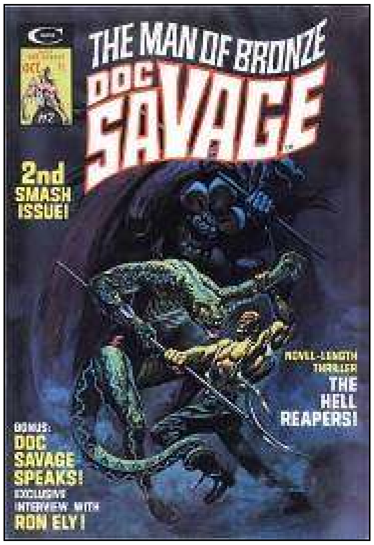
Doc Savage was well acquainted with underground rivers.


A STREET AND SMITH PUBLICATION
DEC. 1933
DOC SAVAGE MAGAZINE
10 CENTS
NRA
A Danger trail leads to THE PHANTOM CITY 80 Page Novel

"The Phantom City"
Doc Savage Magazine # 10
December 1933


DOC SAVAGE COMICS
10¢
Exclusive! Thrilling!

"The Mystery of the
Underground River"
Doc Savage Comics # 20
Oct. 1943


THE MAN OF BRONZE
DOC SAVAGE
OCT
#2
2nd SMASH ISSUE!
NOVEL-LENGTH THRILLER THE HELL REAPERS!
BONUS: DOC SAVAGE SPEAKS! EXCLUSIVE INTERVIEW WITH RON ELY!

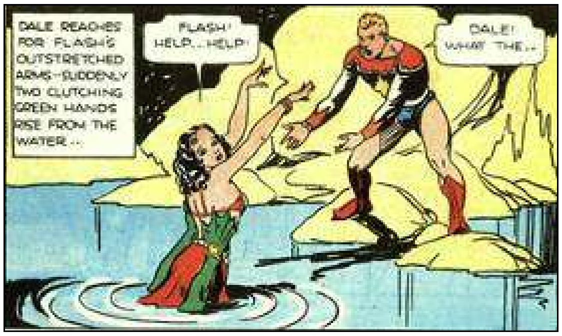
"The Hell Reapers"
Doc Savage Magazine
CC series # 2
Oct. 1975

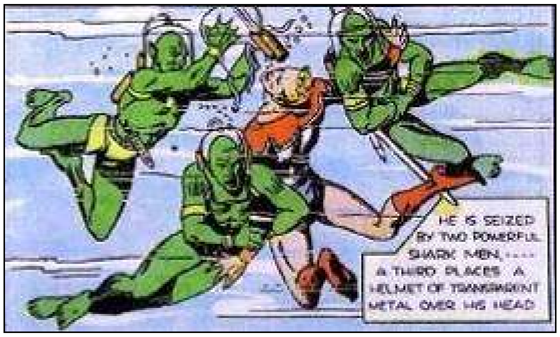
"The Phantom City," abode to an ancient race of white-haired people and said to possess a fabulous trove of platinum, is deep in the lethal desert of the Arabian desert, reachable by a nerve-wracking journey down an underground river.

"The Mystery of the Underground River, or Murder at the Old Red Mill" is a Nick Carter story, a detective who padded Doc's comic book series. This was the final issue.

In "The Hell Reapers," Doc cuts through the polar ice cap, only to be caught in a deadly whirlpool and emerge into a radiation-lit subterranean land, home to mysterious lizard-folk. The villain Rutter, a mutant seeking his fortune exploiting the uranium. When Rutter goes berserk, blasting the caverns, a rock fall blocks the outlet of the underground river and the subterranean world begins to flood.

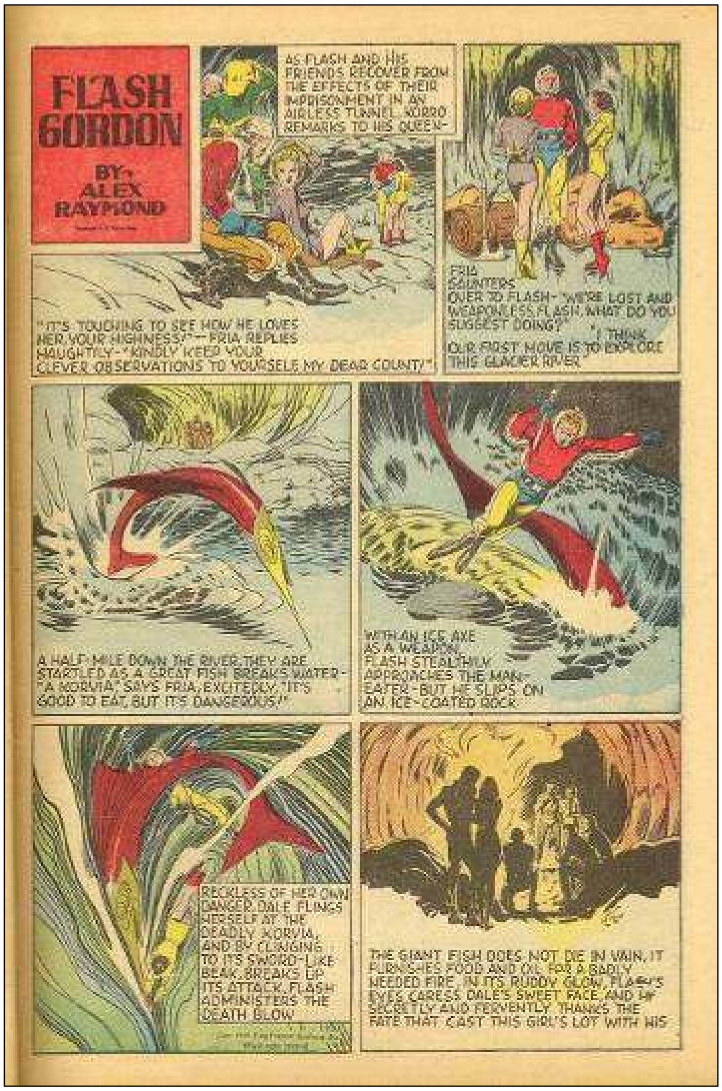
In "On the Planet Mongo," Flash Gordon, March 18, 1934, Flash, Dale and Thun are swept away by the underground river. Thun is knocked unconscious and washes up on a rock, just as Dale is pulled underwater. Flash dives in to rescue her, and is seized by green scaly Shark Men wearing air helmets.

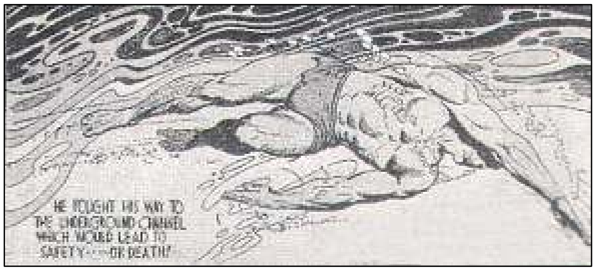

DALE REACHES FOR FLASH'S OUTSTRETCHED ARMS--SUDDENLY TWO CLUTCHING GREEN HANDS RISE FROM THE WATER--
FLASH! HELP...HELP!
DALE! WHAT THE..


HE IS SEIZED BY TWO POWERFUL SHARK MEN,.... A THIRD PLACES A HELMET OF TRANSPARENT METAL OVER HIS HEAD

A page from the Flash Gordon # 10 reissue of 1938, 39 and 40 Sunday strips.

Flash fights his way an underground river and encounters a monster. The others pull him to safety when his lifeline goes slack.


FLASH GORDON
BY: ALEX RAYMOND
AS FLASH AND HIS FRIENDS RECOVER FROM THE EFFECTS OF THEIR IMPRISONMENT IN AN AIRLESS TUNNEL, KORRO REMARKS TO HIS QUEEN-
"IT'S TOUCHING TO SEE HOW HE LOVES HER, YOUR HIGHNESS!"--FRIA REPLIES HAUGHTILY--"KINDLY KEEP YOUR CLEVER OBSERVATIONS TO YOURSELF, MY DEAR COUNT!"
FRIA SAUNTERS OVER TO FLASH- "WE'RE LOST AND WEAPONLESS, FLASH. WHAT DO YOU SUGGEST DOING?" "I THINK OUR FIRST MOVE IS TO EXPLORE THIS GLACIER RIVER"
A HALF-MILE DOWN THE RIVER, THEY ARE STARTLED AS A GREAT FISH BREAKS WATER- "A KORVIA," SAYS FRIA, EXCITEDLY, "IT'S GOOD TO EAT, BUT IT'S DANGEROUS!"
WITH AN ICE AXE AS A WEAPON, FLASH STEALTHILY APPROACHES THE MAN-EATER--BUT HE SLIPS ON AN ICE-COATED ROCK
RECKLESS OF HER OWN DANGER, DALE FLINGS HERSELF AT THE DEADLY KORVIA, AND BY CLINGING TO ITS SWORD-LIKE BEAK, BREAKS UP ITS ATTACK. FLASH ADMINISTERS THE DEATH BLOW
THE GIANT FISH DOES NOT DIE IN VAIN. IT FURNISHES FOOD AND OIL FOR A BADLY NEEDED FIRE. IN ITS RUDDY GLOW, FLASH'S EYES CARESS DALE'S SWEET FACE AND HE SECRETLY AND FERVENTLY THANKS THE FATE THAT CAST THIS GIRL'S LOT WITH HIS


HE FOUGHT HIS WAY TO THE UNDERGROUND CHANNEL WHICH WOULD LEAD TO SAFETY----OR DEATH!

We of course met Tarzan in Chapter 20, More Boys Club Serials, but let us reintroduce him as a character with comic-strip adventures not conceived by Edward Rice Burroughs. To the right, a frame from March 16, 1941.

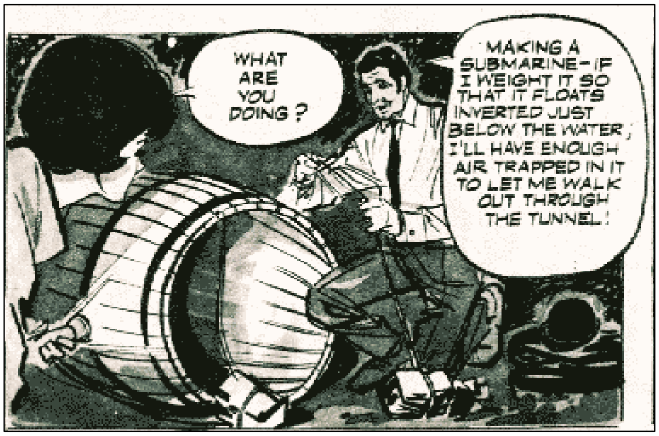
> *He fought his way to the underground channel which would lead to safety -- or death!*

Most typically, comics became TV shows, but in some cases, the order reversed.

TV
Starts today—
THE AVENGERS
COMIC
6D

"Seeds of Destruction," The Avengers in TV Comic # 894, February 1969.

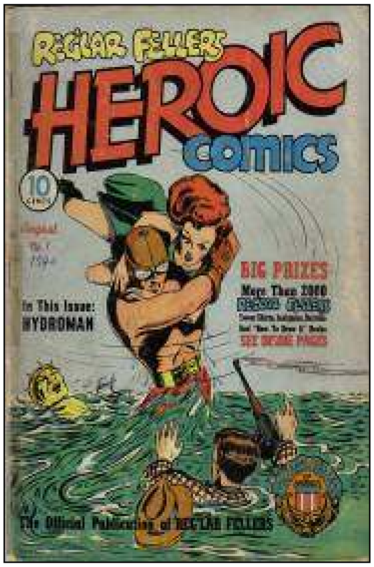
Steed and Tara King find explorer Sir Edmund Whittington held prisoner in a cave. As the roof begins to collapse, the three are trapped with an underground river before them, not a problem when Steed constructs a makeshift submarine from a barrel.


WHAT ARE YOU DOING ?
MAKING A SUBMARINE—IF I WEIGHT IT SO THAT IT FLOATS INVERTED JUST BELOW THE WATER, I'LL HAVE ENOUGH AIR TRAPPED IN IT TO LET ME WALK OUT THROUGH THE TUNNEL!

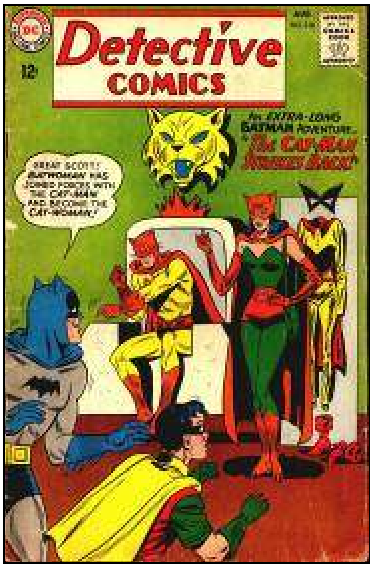
These are but extraordinary human heroes, however, as they lack supernatural powers. The ones with extra endowments, the superheroes, that is, have their underground river challenges even more taxing.

Super Heroes

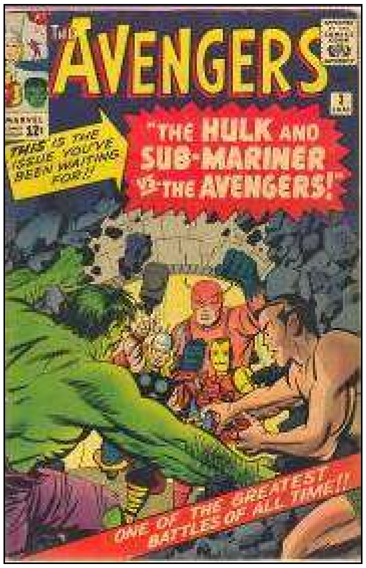
We'll begin with nine covers.


R-EG'LAR FELLERS
HEROIC COMICS
10 CENTS
BIG PRIZES
In This Issue: HYDROMAN
The Official Publication of REG'LAR FELLERS

"Underground River"
Tad of the Tanbark Heroic Comics # 1
August 1940


DC
Detective COMICS
12¢
An EXTRA-LONG BATMAN ADVENTURE... "The CAT-MAN STRIKES BACK!"
GREAT SCOTT! BATWOMAN HAS JOINED FORCES WITH THE CAT-MAN AND BECOME THE CAT-WOMAN!

"The Cat-Man Strikes Back"
Detective Comics # 318
August 1963

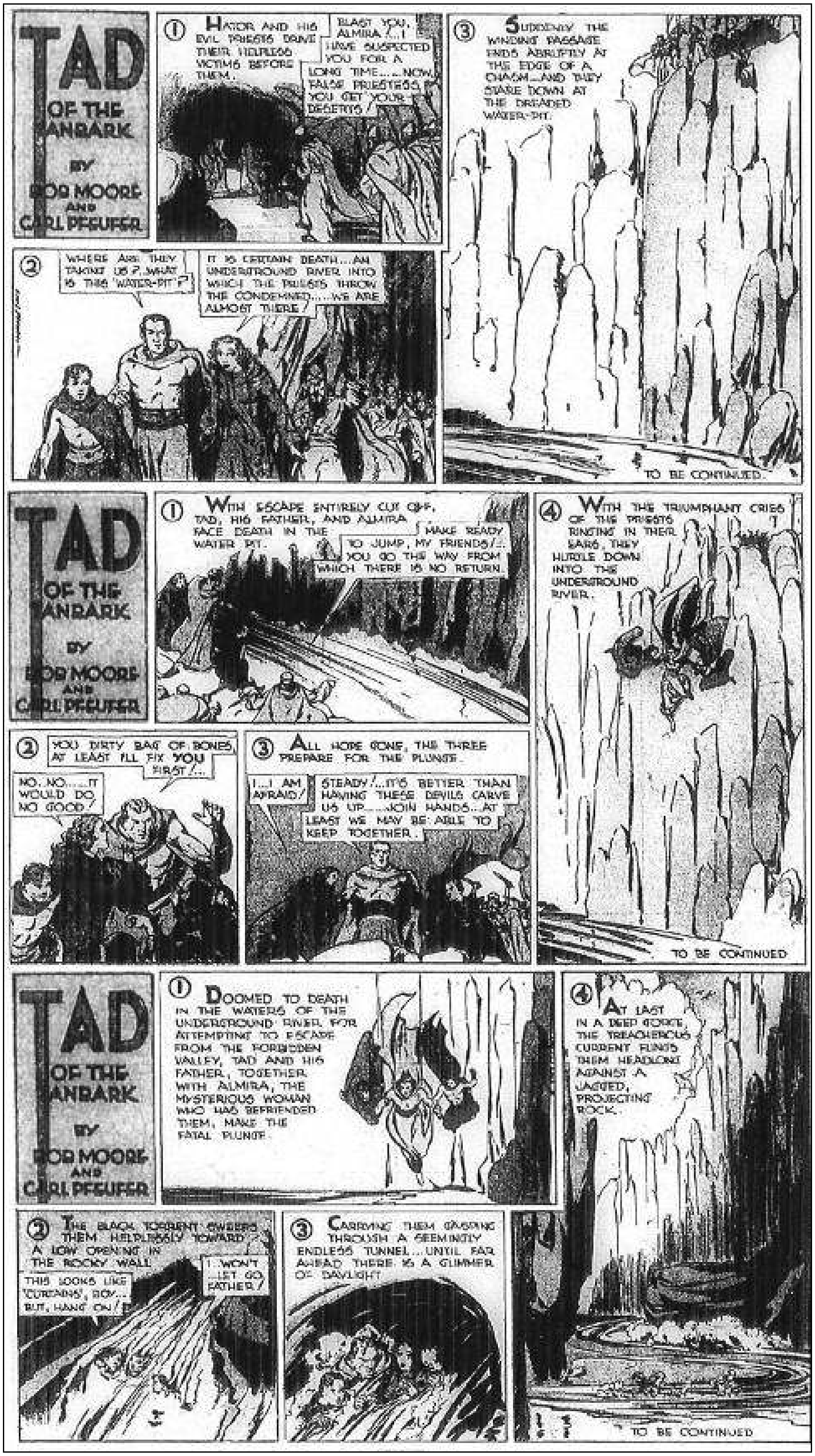

THE AVENGERS
MARVEL 12¢
THIS IS THE ISSUE YOU'VE BEEN WAITING FOR!!
"THE HULK AND SUB-MARINER VS. THE AVENGERS!"
ONE OF THE GREATEST BATTLES OF ALL TIME!!

"The Hulk and Sub-Mariner vs. the Avengers"
Avengers # 3
January 1964

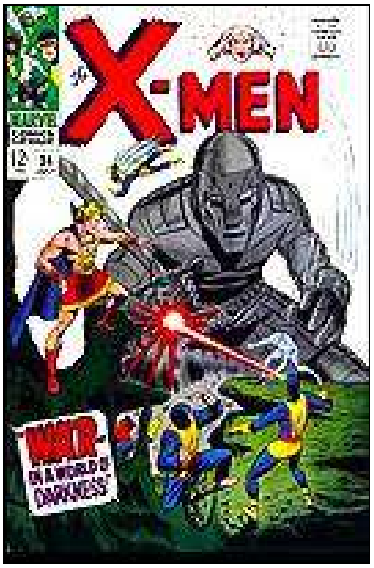
Tad of the Tanbark shows the peril of another underground river.

An encounter with Batwoman results in Cat-Man falling hard for the beautiful heroine and inviting her to join him as "the king and queen of crime." Batman and Robin discover their adversary's true identity and trail him to an underground catacomb, where Cat-Man seems to perish when he plunges into a raging underground river. Cat-Man will of course arise decades hence, as supervillans rarely die.

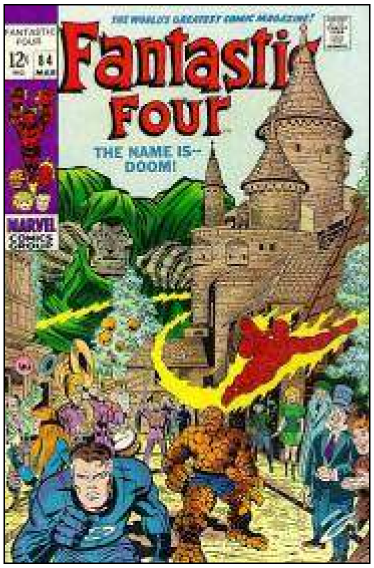
And while we're on the subject of Tad, here are the April 24, May 1 and May 8, 1938, newspaper comic. Tad of the Tanbark, it seems, has a propensity for underground river escapes.


TAD OF THE TANBARK
BY BOB MOORE AND CARL PFEUFER
① HATOR AND HIS EVIL PRIESTS DRIVE THEIR HELPLESS VICTIMS BEFORE THEM.
BLAST YOU, ALMIRA!...I HAVE SUSPECTED YOU FOR A LONG TIME.....NOW, FALSE PRIESTESS, YOU GET YOUR DESERTS!
② WHERE ARE THEY TAKING US?..WHAT IS THIS 'WATER-PIT'?
IT IS CERTAIN DEATH....AN UNDERGROUND RIVER INTO WHICH THE PRIESTS THROW THE CONDEMNED.....WE ARE ALMOST THERE!
③ SUDDENLY THE WINDING PASSAGE ENDS ABRUPTLY AT THE EDGE OF A CHASM...AND THEY STARE DOWN AT THE DREADED WATER-PIT.
TO BE CONTINUED.
TAD OF THE TANBARK
BY BOB MOORE AND CARL PFEUFER
① WITH ESCAPE ENTIRELY CUT OFF, TAD, HIS FATHER, AND ALMIRA FACE DEATH IN THE WATER PIT.
MAKE READY TO JUMP, MY FRIENDS!...YOU GO THE WAY FROM WHICH THERE IS NO RETURN.
② YOU DIRTY BAG OF BONES, AT LEAST I'LL FIX YOU FIRST!...
NO..NO.....IT WOULD DO NO GOOD!
③ ALL HOPE GONE, THE THREE PREPARE FOR THE PLUNGE.
I...I AM AFRAID!
STEADY!...IT'S BETTER THAN HAVING THESE DEVILS CARVE US UP.....JOIN HANDS...AT LEAST WE MAY BE ABLE TO KEEP TOGETHER.
④ WITH THE TRIUMPHANT CRIES OF THE PRIESTS RINGING IN THEIR EARS, THEY HURTLE DOWN INTO THE UNDERGROUND RIVER.
TO BE CONTINUED
TAD OF THE TANBARK
BY BOB MOORE AND CARL PFEUFER
① DOOMED TO DEATH IN THE WATERS OF THE UNDERGROUND RIVER FOR ATTEMPTING TO ESCAPE FROM THE FORBIDDEN VALLEY, TAD AND HIS FATHER, TOGETHER WITH ALMIRA, THE MYSTERIOUS WOMAN WHO HAS BEFRIENDED THEM, MAKE THE FATAL PLUNGE.
② THE BLACK TORRENT SWEEPS THEM HELPLESSLY TOWARD A LOW OPENING IN THE ROCKY WALL
THIS LOOKS LIKE 'CURTAINS', BOY... BUT, HANG ON!
I WON'T ...LET GO FATHER!
③ CARRYING THEM GASPING THROUGH A SEEMINGLY ENDLESS TUNNEL...UNTIL FAR AHEAD THERE IS A GLIMMER OF DAYLIGHT
④ AT LAST IN A DEEP GORGE, THE TREACHEROUS CURRENT FLINGS THEM HEADLONG AGAINST A JAGGED, PROJECTING ROCK.
TO BE CONTINUED

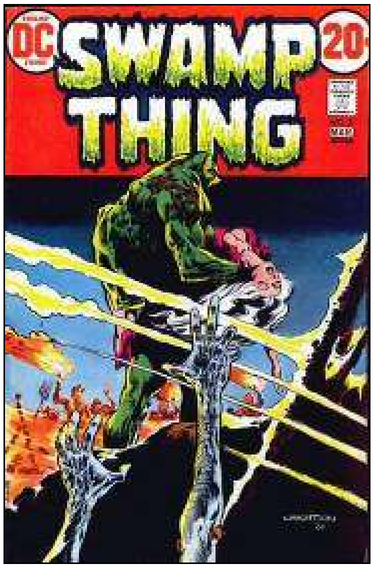
In Avengers # 3, Iron Man uses his magnetic resistors to send a surge of boulders at the Hulk, but the green giant uses a cactus to fight back. Meanwhile, the Wasp and Giant-Man -- who has shrunk to the size of an insect for cross-country travel -- go subterranean, where they enlist the aid of an army of ants to redirect an underground river to collapse the ground under the Hulk.


X-MEN
MARVEL COMICS GROUP
12¢
34
WAR-- IN A WORLD OF DARKNESS!

"War in a World of Darkness"
X-Men # 34
July 1967


THE WORLD'S GREATEST COMIC MAGAZINE!
Fantastic Four
12¢
84
MAR
THE NAME IS-- DOOM!
MARVEL COMICS GROUP

"The Name is Doom!"
Fantastic Four # 84
March 1969

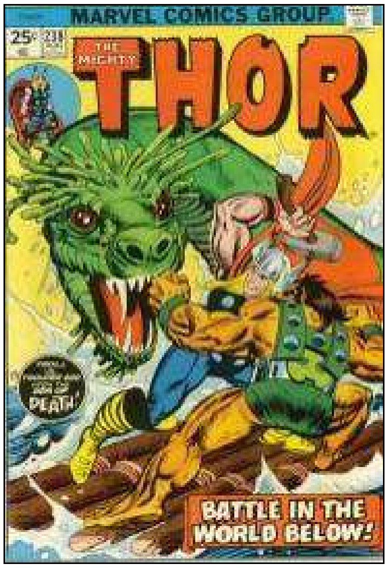

DC
20¢
SWAMP THING
MAR

"The Man Who Wanted Forever"
Swamp Thing # 3
March 1973

The X-Men use an Atomic Powered Earth Borer to follow Tyrannus to his underground palace. Angel, Marvel Girl and Iceman pop out in a cavern bathed in a emerald glow where Mole Man leads them into a trap where they are overcome by mists from an the underground river Lethe. The name should be familiar.

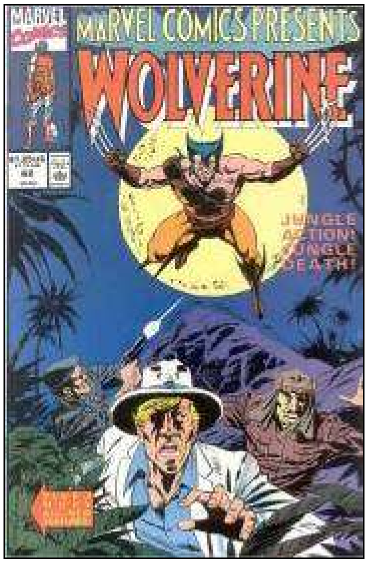
In the Fantastic Four comic, a poor Latverian attempts to escape Dr. Doom via a hidden tunnel in the catacombs of Castle Doom and swimming an underground river to the open sea

Wandering the halls of Arcane's castle, Swamp Thing falls through a broken flagstone and into an underground river. Meanwhile, Lt. Cable, who has tracked the Swamp Thing to this Balkan village, meets Abigail Arcane and all three face a mob of angry villagers.


MARVEL COMICS GROUP
25¢ 238
THE MIGHTY
THOR
BATTLE IN THE WORLD BELOW!

"Night of the Troll!"
Thor # 238
August 1975

Ulik leads Thor to an underground river. Elsewhere, Orrin gets involved in a grape picker's strike. Back in the caverns, Ulik tells Thor his plan: take care of Zotarr while he attacks Geirrodur.

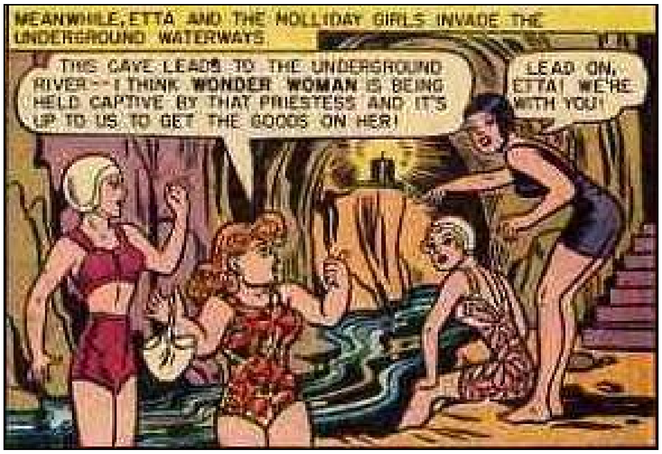

MARVEL COMICS PRESENTS
WOLVERINE
JUNGLE ACTION! JUNGLE DEATH!

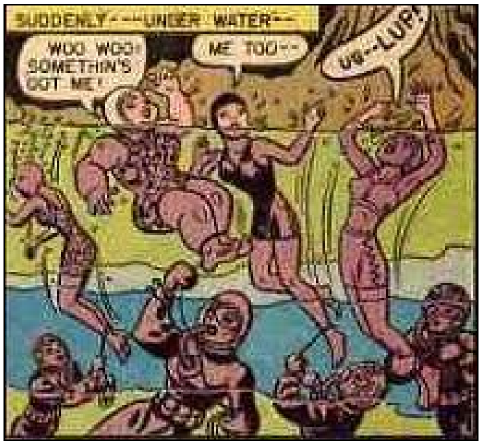
"Sign of the Beast"
Wolverine # 62
November 1990

Wolverine causes a foe to burst into flame, then causes an underground river to geyser and douse the fire.

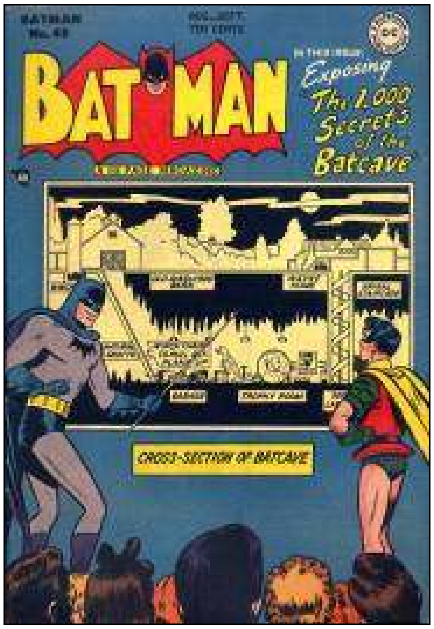
But let us get to some of the more familiar super heroes.

Wonder Woman might not seem to be a Boys Club subject, but bathing suits help. In "The Judgment of Goddess Vultura," Wonder Woman # 25, September 1949, as Etta -- a short, overweight college student -- and her girls swim through the underground river to rescue Wonder Woman, they feel something pulling them underwater!


MEANWHILE, ETTA AND THE HOLLIDAY GIRLS INVADE THE UNDERGROUND WATERWAYS
THIS CAVE LEADS TO THE UNDERGROUND RIVER--I THINK WONDER WOMAN IS BEING HELD CAPTIVE BY THAT PRIESTESS AND IT'S UP TO US TO GET THE GOODS ON HER!
LEAD ON, ETTA! WE'RE WITH YOU!

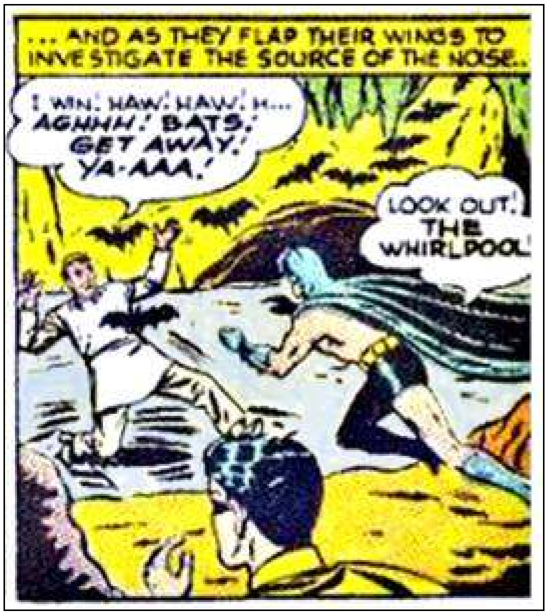

SUDDENLY---UNDER WATER--
WOO WOO! SOMETHIN'S GOT ME!
ME TOO--
UG--LUP!

To quote Eta, "Woo, Woo!"

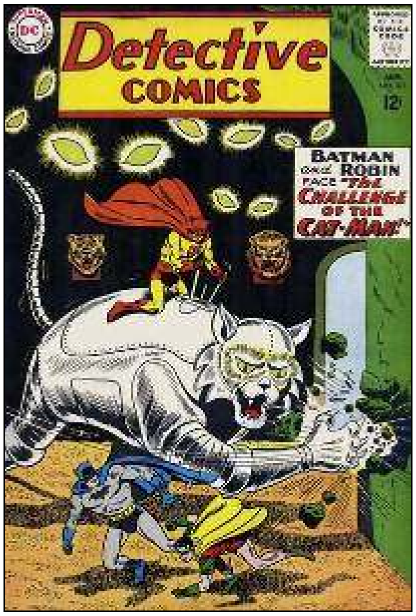

BATMAN No. 48
AUG.-SEPT. TEN CENTS
BATMAN
IN THIS ISSUE: Exposing The 1,000 Secrets of the Batcave
CROSS-SECTION OF BATCAVE

Batman #48, August-September 1948

Behind Batman's right shoulder is labeled, "Natural Grotto."


... AND AS THEY FLAP THEIR WINGS TO INVESTIGATE THE SOURCE OF THE NOISE..
I WIN! HAW! HAW! H... AGHHH! BATS! GET AWAY! YA-AAA!
LOOK OUT! THE WHIRLPOOL!

In the same issue, Wolf Brando, the first criminal to find his way into the Batcave, drowns in the underground stream.


Detective COMICS
12¢
BATMAN and ROBIN FACE "THE CHALLENGE OF THE CAT-MAN!"

Detective Comics #311, January 1963

Batman and Robin trail Cat-Man to an underground catacomb, where their adversary seemed to perish when he plunges into a raging underground river.

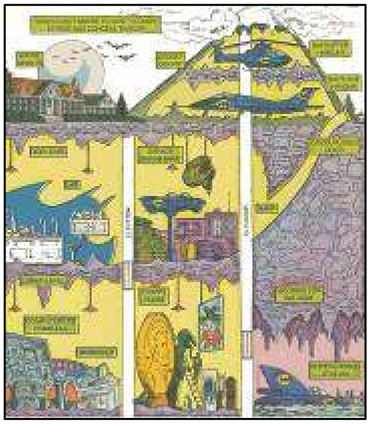
DC COMICS
THE NEW 52!
BATMAN
SCOTT SNYDER
GREG CAPULLO
JONATHAN GLAPION

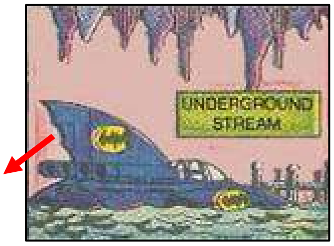
Batman #6, February 2012

Batman discovers the dark beating heart of a sinister organization and uses his knowledge of Gotham's water supply to breach the white marble base of a fountain and dive into the underground river below.

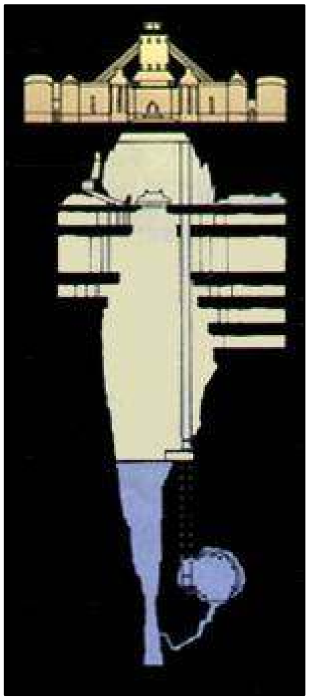
The Batcave underground river is sufficient for hydro-electric power and dockinf the Batboat.

The Batcave layout from DC Comics 1985 Who's Who.




UNDERGROUND STREAM

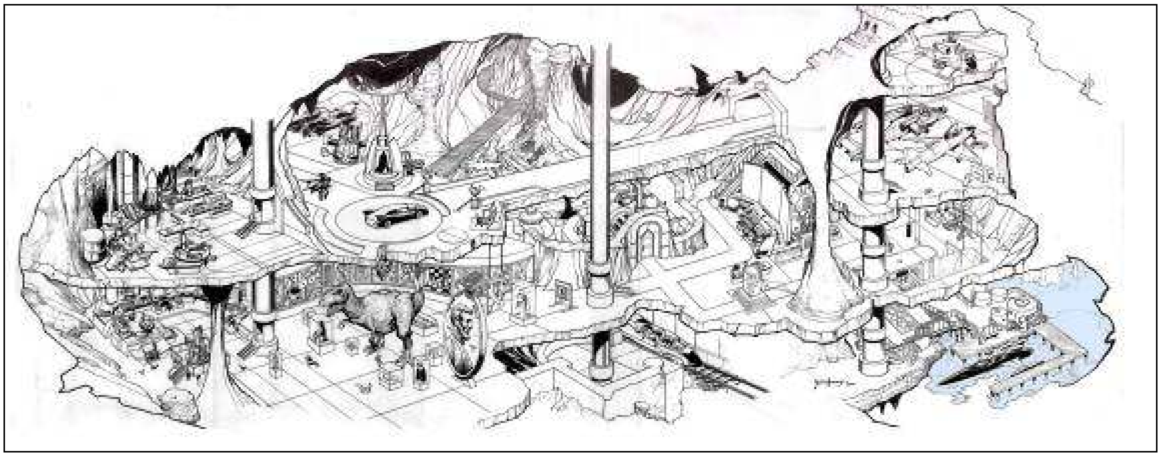
Shown next are elevations of a yet more complex subterranean fortress, the underground river being at sea level and a submarine port 26 meters yet lower. The Batcave entrance to the right resembles a more-natural karst formation.


Wayne Manor
Central Grotto
Labs/Library
Training Area
Storage

Ground Level	200 feet
Main Level	150 feet
Sub-Level 1	138 feet
Sub-Level 2	114 feet
Sub-Level 3	96 feet
Sub-Level 4	84 feet
Sub-Level 5	55 feet
Sub-Level 6	sea level
Sub-Level 7	-84 feet

The mouth of the Batcave, featuring the Batmobile, Batplane and Batboat, as modeled by T 'N' T Hobbies' Science Fiction & Fantasy Model Gallery

Another rendition of Batman's subterranean complex.. The river is indicated in blue.



Guest appearances of one superhero within another's story (at least between those of the same comic book empire) are common. Here's an educationalist's assessment of one involving Robin and Batman, Spiderman and Wonder Woman and an underground river.

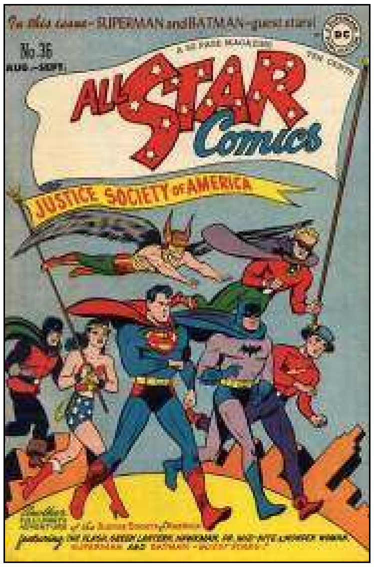
> *By ages 9 and 10 children are able to develop appropriate secondary elements for each of the new primary functions, so that there are two or more well developed episodes. Thus, in one fairly elaborate story, Batman and Robin are in a haunted house. Robin falls through a trapdoor into an underground river, but manages to signal for help and Batman rescues him. Then they hear a scream, think it is a girl in distress and run up to the attic to rescue her. They discover that the scream has come from Spiderman, who throws an extra strong spider net over them, and says that he intends to kill them and run off with Wonder Woman in the Batmobile and live in the Bat Cave. Batman says that he needs a special key for the Batmobile and Bat Cave and when Spiderman comes to get it, they overcome him and put him in jail. The step to embedding true subplots within the primary story structures is not made until later.* -- J.A. Appleyard, Becoming a Reader, The Experience of Fiction from Childhood to Adulthood (1991)

And just as we saved Roy Rogers to close our list of cowboy idols, we've saved the best for last to close out our superhero list.

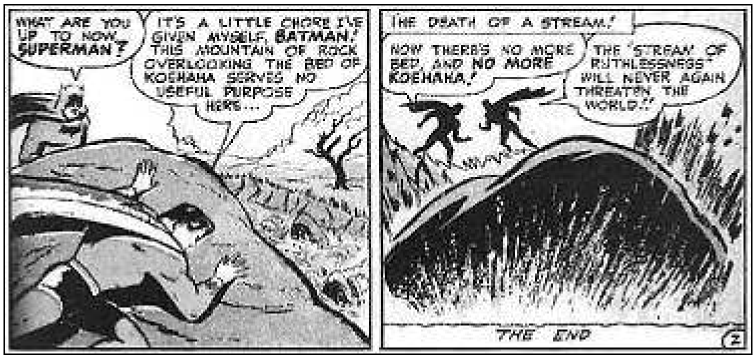
It's a bird! It's a plane! It's Superman!

The longest-running Superman adventure involving an underground river involved the River Koehaha, the legendary Stream of Ruthlessness said to be in Colorado whose waters have the power to wash away the consciences from those who "drown" in it, causing them to become nefarious.

In "5 Drowned Men," All-Star Comics # 36, evil-doer Calvin Stymes takes revenge on five ex-fraternity brothers who traumatized him by immersing them in Stygian waters. Accordingly, the Justice Society of America must deal with five brand-new master criminals. In a mega-star comic book spectacular, Superman, Batman and Wonder Woman assist the JSA in capturing Stymes, but there's more to come!

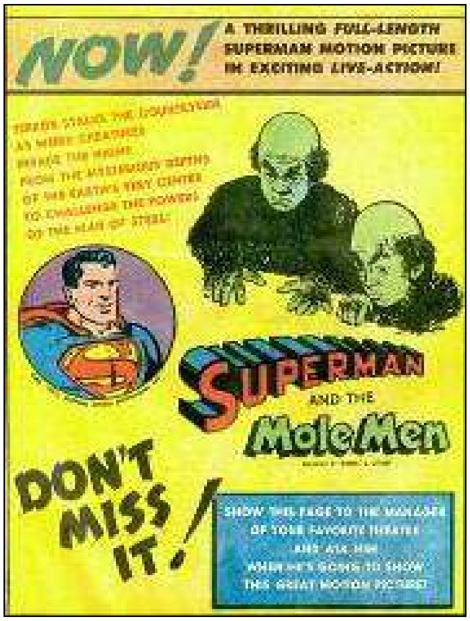

In this issue—SUPERMAN and BATMAN—guest stars!
No. 36
AUG.–SEPT.
All Star Comics
JUSTICE SOCIETY of AMERICA

"5 Drowned Men"
All-Star Comics # 36
August-September 1947

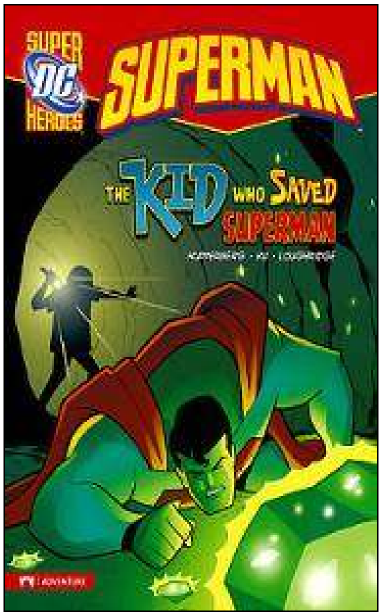

WHAT ARE YOU UP TO NOW, SUPERMAN?
IT'S A LITTLE CHORE I'VE GIVEN MYSELF, BATMAN! THIS MOUNTAIN OF ROCK OVERLOOKING THE BED OF KOEHAHA SERVES NO USEFUL PURPOSE HERE...
THE DEATH OF A STREAM!
NOW THERE'S NO MORE BED, AND NO MORE KOEHAHA!
THE "STREAM OF RUTHLESSNESS" WILL NEVER AGAIN THREATEN THE WORLD!
THE END

Superman manages to send the Koehaha underground, but the waters will reemerge in 1984 when Infinity, Inc., a younger group of superheroes, alternatively fights against and joins with the older superheroes, depending upon who's been "drowned." It requires a time machine and the Infinity, Inc. # 3-10 series to sort things out and to dispatch the latest villain, Ultra-Humanite.

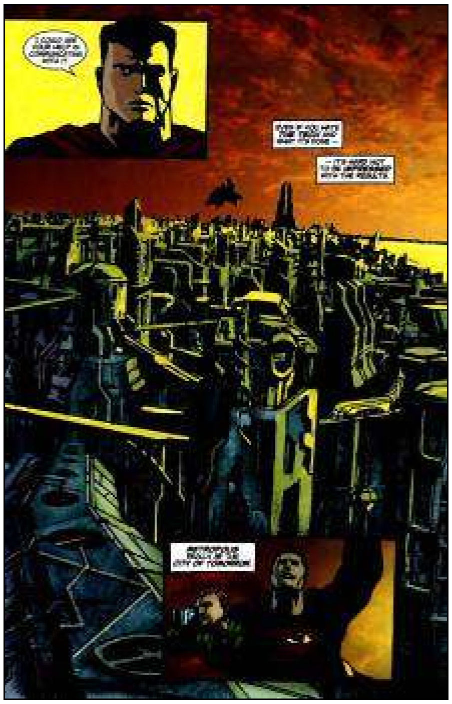
Here are a few of the Man of Steel's quicker underground river adventures.


NOW!
A THRILLING FULL-LENGTH SUPERMAN MOTION PICTURE IN EXCITING LIVE-ACTION!
SUPERMAN AND THE Mole Men
DON'T MISS IT!
SHOW THIS PAGE TO THE MANAGER OF YOUR FAVORITE THEATRE AND ASK HIM WHEN HE'S GOING TO SHOW THIS GREAT MOTION PICTURE!

Superman and the Mole Men (1951)


SUPER DC HEROES
SUPERMAN
THE KID WHO SAVED SUPERMAN

The Kid who Saved Superman (2009) by Paul Kupperberg



A computer virus allows Brainiac 13 to travel from the 64th century to the present and transform Metropolis into a futuristic ultra-city of his dewsgn. Collapsing infrastructure is repaired under the citizens' feet. Sewers become pristine waterways patrolled by genetically engineered creatures who consume waste. A homeless man finds a rubber dinghy and reinvents himself as a new Charon.

But what is Brainiac's intent? Surely not to steal all the world's electricity!

Superman #154, March 2000

In Superman and the Mole Men (1951), an oil well breaks through to the center of the earth and the Mole Men ascend, causing a wave of hysteria that only Superman can quell.

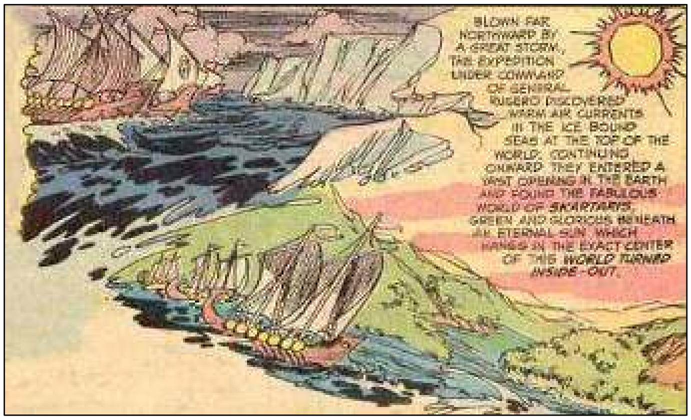
The Superman animated series, "The Beast Beneath These Streets," November 19, 1988, is set in a part of Metropolis buried a hundred years ago wher Morpheus makes a machine that allows him to steal the powers of animals. The evil physician lures Superman to his lair and throws the super hero into an underground river, but Superman reverses the polarity and gains his powers back.

Hakeem Bennett, a Brooklyn special education student who won an essay contest, was made the title character of Paul Kupperberg's The Kid who Saved Superman (2009). A bit of the action,

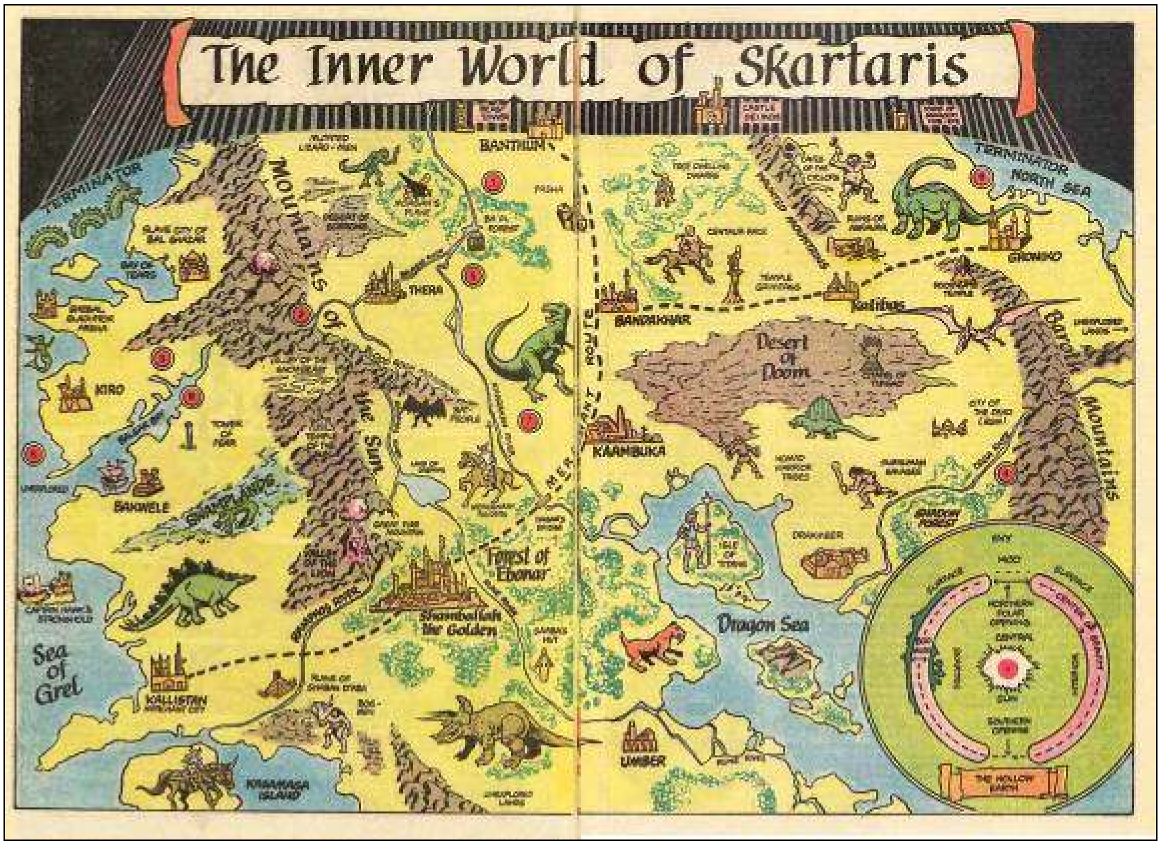
> *Splash! Hokeem sputtered and coughed. The cold, rushing water of an underground river swept hem deeper into the cave. His arms flailed wildly, reaching for something to grab.*
>
> *"Help!" he called out.*
>
> *When the cave floor split open, Hakeem had fallen into the frigid water. The river rushed along and spilled through a hole in the cave wall. It poured out into a large underground pool, carrying Hakeem like a leaf caught in a storm.*

In Skartaris, a comic book series debuted in 1975, US Air Force pilot Travis Morgan discovers through a North Pole entrance the inner-surface land of Skartaris where a miniature sun is suspended within our hollow globe. A moon orbits this sun, shadowing areas of Skartaris from time to time.

We, of course, are most interested in the hydrology, and indeed we find oceans to sail, but they're rather standard adventure-book seas.


BLOWN FAR NORTHWARD BY A GREAT STORM, THE EXPEDITION UNDER COMMAND OF GENERAL RUGERO DISCOVERED WARM AIR CURRENTS IN THE ICE BOUND SEAS AT THE TOP OF THE WORLD. CONTINUING ONWARD THEY ENTERED A VAST OPENING IN THE EARTH AND FOUND THE FABULOUS WORLD OF SKARTARIS, GREEN AND GLORIOUS BENEATH AN ETERNAL SUN WHICH HANGS IN THE EXACT CENTER OF THIS WORLD TURNED INSIDE-OUT.

Here's the map of the underworld, its seas, lakes and rivers and its golden metropolis filled with advanced Atlantean technology, Shamballah, an underground destination we'll not visit until Chapter 71. Note the Hollow Earth cross-section in the corner.

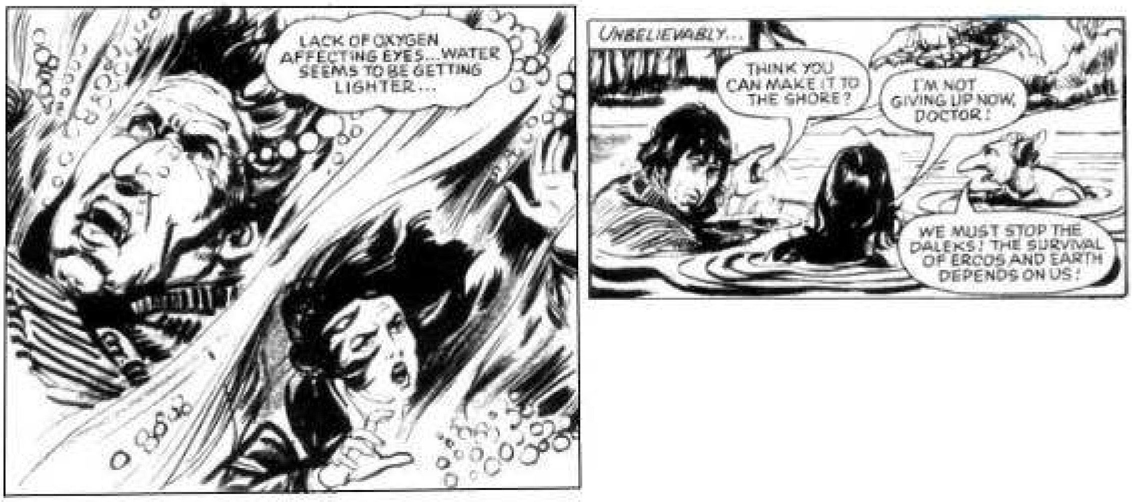

The Inner World of Skartaris
TERMINATOR
TERMINATOR NORTH SEA
BANTHUN
Mountains of the Sun
THERA
KIRO
BANDAKHAR
Desert of Doom
Forest of Ebonar
Shamballah the Golden
Dragon Sea
Sea of Grel
KALLISTAN
UMBER
THE HOLLOW EARTH

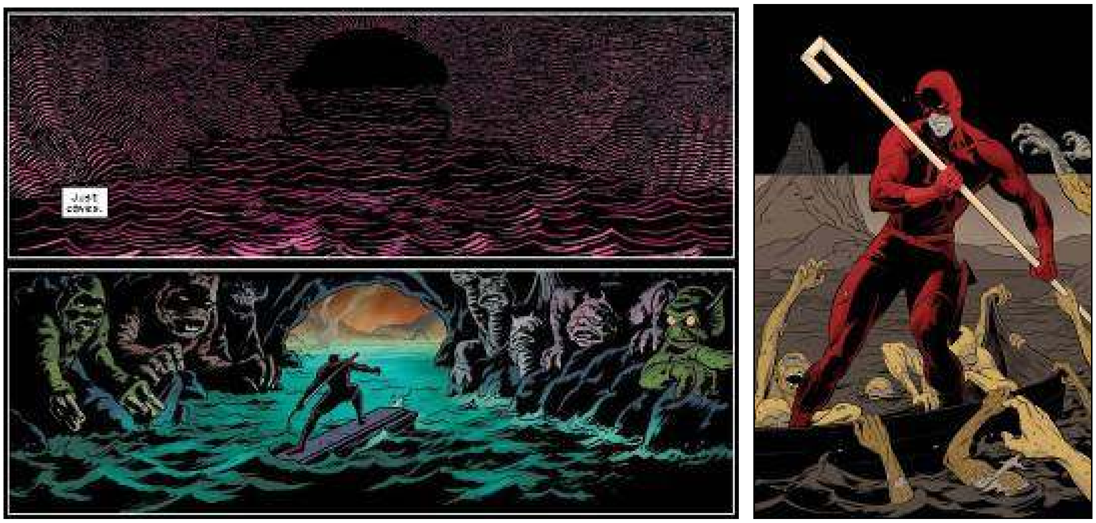
All in all, Skartaris is an amalgamation of Symmes' cosmology, Burroughs' Pellucidar, Admiral Byrd's aerial detour, Jules Verne's adventures of ecxploration and any number of hackneyed spinoffs we've perused in earlier chapters.

And of course there's the quirky Dr. Who. From TV Comic, Dr. Who "The Dalek Revenge" January 24, 1976,

> *Entombed by the Daleks, the Doctor, Sarah-Jane and Ticon have followed the course of an underground river which they hope will get them to the surface. With now way back, they leap*

inti a vast whirlpool which the Doctor considers might be a natural siphon. As there lungs begin to fail, so do their senses or reality. For they suddenly seem to be shooting upwards.

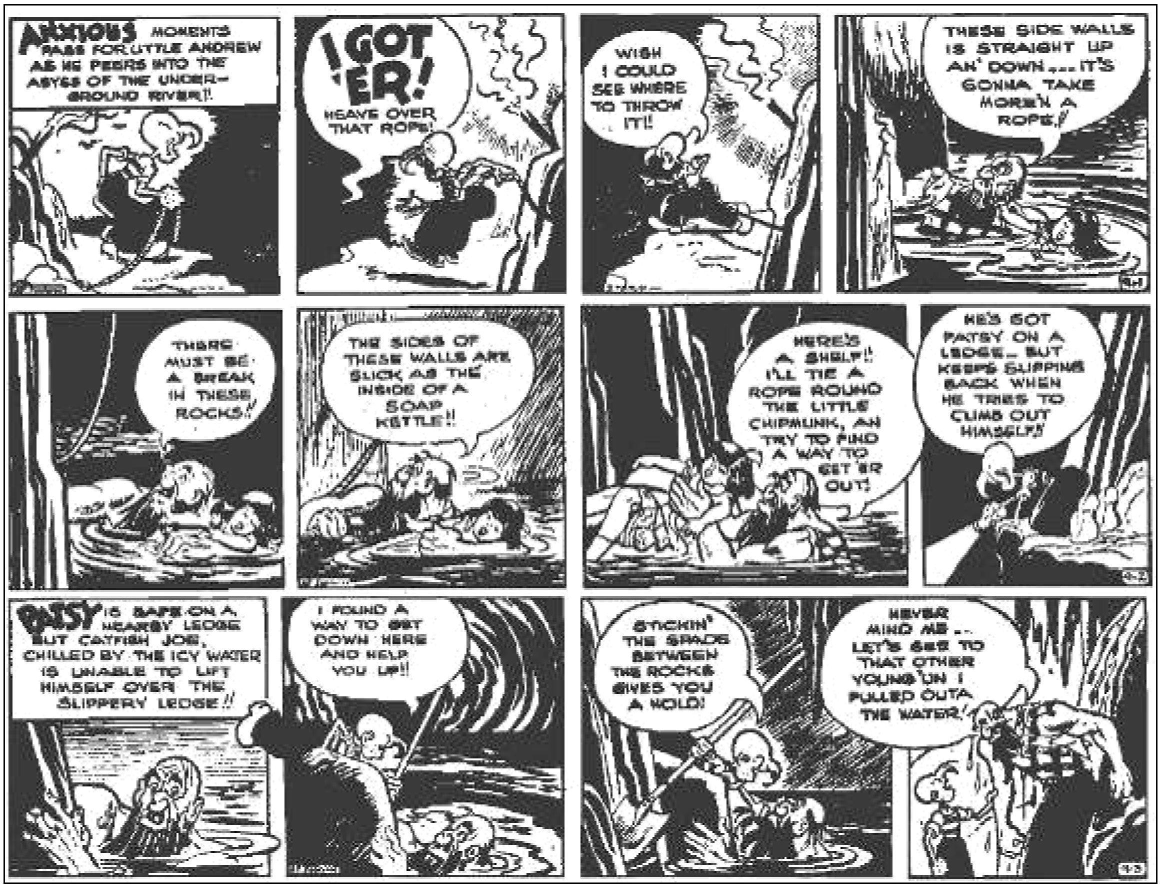

LACK OF OXYGEN AFFECTING EYES...WATER SEEMS TO BE GETTING LIGHTER...
UNBELIEVABLY...
THINK YOU CAN MAKE IT TO THE SHORE?
I'M NOT GIVING UP NOW, DOCTOR!
WE MUST STOP THE DALEKS! THE SURVIVAL OF ERCOS AND EARTH DEPENDS ON US!



The artwork of Daredevil #9, February 2012, is unabashedly Charonic (Chapter 33, Twenty-Five Centuries of Subterranean Portraits), but as Daredevil is a superhero, not an aged and morose boatman, we include him here.

And Just Regular Girls

Even an underground river isn't going to stop a determined kid. From "The Adventures of Patsy," September 1-3, 1943.


ANXIOUS MOMENTS PASS FOR LITTLE ANDREW AS HE PEERS INTO THE ABYSS OF THE UNDER-GROUND RIVER!!
I GOT 'ER! HEAVE OVER THAT ROPE!
WISH I COULD SEE WHERE TO THROW IT!!
THESE SIDE WALLS IS STRAIGHT UP AN' DOWN.... IT'S GONNA TAKE MORE'N A ROPE!!
4-1
THERE MUST BE A BREAK IN THESE ROCKS!!
THE SIDES OF THESE WALLS ARE SLICK AS THE INSIDE OF A SOAP KETTLE!!
HERE'S A SHELF!! I'LL TIE A ROPE ROUND THE LITTLE CHIPMUNK, AN TRY TO FIND A WAY TO GET 'ER OUT!
HE'S GOT PATSY ON A LEDGE.. BUT KEEPS SLIPPING BACK WHEN HE TRIES TO CLIMB OUT HIMSELF!!
4-2
PATSY IS SAFE ON A NEARBY LEDGE BUT CATFISH JOE, CHILLED BY THE ICY WATER IS UNABLE TO LIFT HIMSELF OVER THE SLIPPERY LEDGE!!
I FOUND A WAY TO GET DOWN HERE AND HELP YOU UP!!
STICKIN' THE SPADE BETWEEN THE ROCKS GIVES YOU A HOLD!
NEVER MIND ME -- LET'S SEE TO THAT OTHER YOUNG'UN I PULLED OUTA THE WATER!
4-3

The Future

And where is comic book culture heading?

It's heading to graphic novels.

REX MUNDI
The River Underground

Rex Mundi is a comic book miniseries set in a 1930s Paris where magic is real and kings and Popes are still in power. In Book 2, The River Underground (2005), Dr. Julien Saunière follows the trail of conspiracy that extends to the walls of Jerusalem during the first crusade.

Though the comic book media migrates between paper and film, the plots rely on standard settings, that of an underground river being very much a favorite.

CHAPTER 25

RADIO DAYS AND SATURDAY MATINEES

Underground rivers tend to meander toward studios, albeit radio, television or cinema. This chapter deals with fast-paced radio, television and B-grade cinema adventures, often serialized, aimed at the Boys Club audience.

We'll try not to repeat what's elsewhere in our journey. Illustrations in Chapters 16 and 17, chapters about English and Continental fiction, included scenes from film adaptations. Many books cited in the chapters dealing with juvenile fiction were reworked into radio, television and movie releases. The name-brand funny-page characters of Chapter 24 are regularly marketed in multimedia formats. In Chapter 58, The Grand Tour, European Sewers of Distinction, we'll hawk cinema tickets appropriate to our settings. Thus this chapter's bigger than just this chapter.

Radio Days

Any up-to-date Boys Clubhouse would of course have had its clubhouse radio.

Flash Gordon never seemed to be far from underground waters. From the Flash Gordon radio episode of April 27, 1935,

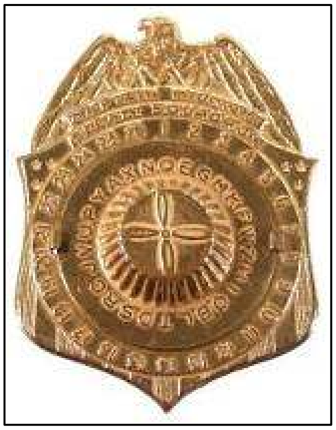
> *Flash Gordon and Prince Thun, with Dale between them, dash into the secret passage beneath the idol. The way becomes steeper. They slip and fall. Down! Down! A hundred feet or more into a whirling underground river. They're swept along down a raging current and over a falls into a lake. With the powerful strokes of a champion swimmer, Flash sets out for the shore, towing Dale by the hair. They reach the shore, and as Flash reaches down to drag Dale to safety,* {We hear her scream.} *she screams and disappears beneath the calm surface of the lake, clutched in two powerful green, scaly arms. With no thought of his own safety, Flash Gordon dives to Dale's rescue* [Water sounds] *and finds an adventure stranger than any which has gone before.*

The November 15, 1939, episode of Captain Midnight, "Chuck Falls into Underground River," begins,

> *Last time, you remember, Chuck Ramsey, accompanied by Patsy Donovan and the Mexican boy Pablo, were exploring the interior of the cave in which Patsy and her mother had been taking shelter. They found an underground river and in following along its shore, approached a roaring waterfall.*

As we anticipate from the title, Chuck falls in, but as he's a member of the Captain's Secret Squadron, he's saved and the adventure continues.

As Secret Squadron members ourselves, we have our own Captain Midnight decoder.

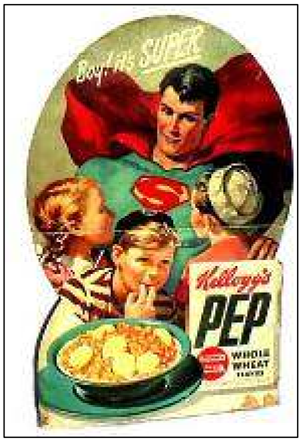


Master Code X-25

21	26	15	2	17	3	17	11	21	26	15		17	10	20	2	17
																.

To decode, set X on the inner wheel to match 25 on the outer, as in the photo. 21 corresponds U. 26 is N. Carry on, Secret Squadron Member.

The Adventures of Superman radio show that aired from 1940 to 1951 had numerous underground rivers.



On March 4, 1946, Jimmy Olsen falls into an underground river on the moon where hundreds of yellow eyes gleam from the darkness. This calls for a friend.

On September 9, 1948, Jimmy almost drowns in an underground river when his canoe sinks. He finds the Silver Buffalo, but is frozen in place! Only one can save him!

In the February 7, 1942, Adventures of Red Ryder radio serial "Trouble on the Shogono Trail," Little Beaver nearly drowns as he investigates cattle being rustled through an underground river.

The FBI in Peace and War featured a clattering teletype to notify listeners that justice was near. The September 23, 1948, broadcast was "The Underground River," but as the episode is no longer available, we don't know why.

The November 6, 1951, episode of Mysterious Traveler, "Behind the Locked Door," is set almost entirely in the dark, depending on sound and plot to foster a sense of menace

A professor, his assistant Martin, and their Native American guide discover a cave deliberately blocked with stones and blast their way in. There they find the remains of a wagon train which the professor deduces was forced into the cavern by attackers who then sealed the mouth.

In the honeycombed maze is an underground river with fish bones piled along its banks.

When the guide flees and is found clawed to death, the professor grasps the horrifying possibility that the trapped wagon train had found the river and their descendants, blind with other senses magnified, yet survived.

Flashlights fail and the scientist is likewise killed. Martin is attacked soon thereafter, but regains consciousness with "a heavy, calloused hand" washing his face. Desperate, he jumps into the river and his savior jumps after him. Martin again passes out and when he wakes a second time, he and the creature are on a sand bar on the Colorado River.

The story of terror, perfect for radio. The twist at the end is the only possible effective ending.

In “The Unknown,” Family Theater, September 16, 1953, a reporter and a fading socialite descend by cable beneath the Pyrenees and trek along an uncharted passage until they encounter an impassable underground gorge.

The woman: *What do you think is down there?*

The man: *More limestone.*

The woman: *No, there’s something more. There’s mystery in all that blackness... All my life, I’ve been running, I’ve been afraid. Now I know it’s got to stop.*

Against her partner's protestations, she lowers herself into the darkness, pursuing the distant rumble of an underground river. Then something appears which she describes in unmistakably religious terms.

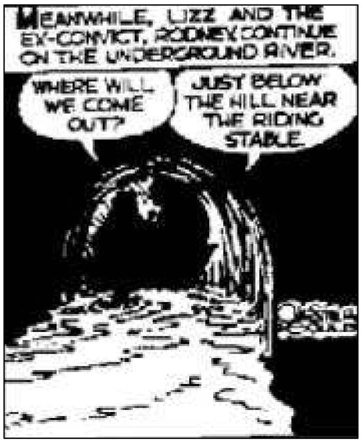
The woman: *Oh, Dick you should see!… A huge cave, back under the shelf. It’s like a cathedral!”*

The man: *Can you see the river?*

The woman: *No, but I detect a little spring, sort of a, sort of a tiny little waterfall, bursting out of the rock. It looks almost like a fount. Oh, Dick. I’ve got to go in there!*

Perhaps it's an allusion to the fount of Exodus 17:6 (Chapter 4, The Cross). In her own way, she finds what she was seeking -- the courage to live.

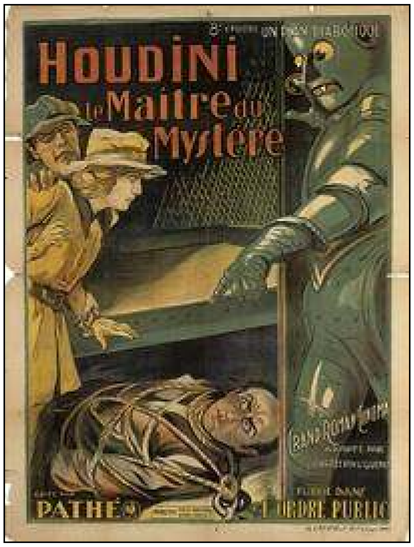
Gumshoes must deal with counterfeiters who duck underground. From the December 6, 1956, Dick Tracy strip, the underground river escape tunnel known only to Rodney.


MEANWHILE, LIZZ AND THE EX-CONVICT, RODNEY CONTINUE ON THE UNDERGROUND RIVER.
WHERE WILL WE COME OUT?
JUST BELOW THE HILL NEAR THE RIDING STABLE.

B-Grade Cinema

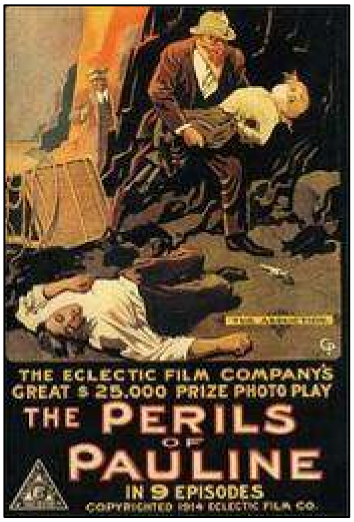
A Boys Club of years past would never have missed the Saturday matinee at the Bijou.

Harry Houdini starred in The Master Mystery (1919), a 15-part film serial released simultaneously with the novel of the same name in which Quentin Locke, scientist, agent of the U.S. Department of Justice and escape artist extraordinaire, takes on a band of criminals and a metal robot, "The Automaton," which has been robbing inventors of their patent rights.


HOUDINI
le Maître du Mystère
PATHÉ
L'ORDRE PUBLIC

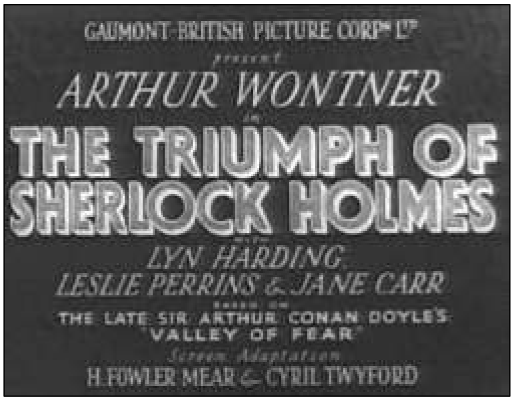
> *The fiendish plan was simple -- to hang him and then to cut the rope. His body would go hurtling down to the subterranean river below and be carried out to sea.*
>
> *The hypnotist reversed the lever. The trap-door closed. Locke was dragged beneath the rope and it was adjusted around his neck.*
>
> *Even in this awful moment his sole thought was of Eva. Would they throw her, unconscious, down the same yawning trap?*
>
> *With a crash the trap was sprung, with the pit yawning beneath it. Struggling, striking, grappling with his assailants, Locke managed to hurl three of them to their deaths in the underground river below.*
>
> *Horror-stricken at the fate of their companions, the other emissaries stepped back, when, to add to their confusion, Zita, with remarkable strength for so frail a girl, lifted the stand of mirrors and hurled it among them.*

The Perils of Pauline (1933) was a serial remake of the 1914 silent original. In the episode "Dangerous Depths," Pauline and Warde are seized by Bashan, but manage into a side room and lock the door. Unable to open the door again, the two try another way out—only to have the floor collapse beneath them, dumping the pair into an underground river.


THE ECLECTIC FILM COMPANY'S
GREAT $25,000 PRIZE PHOTO PLAY
THE PERILS OF PAULINE
IN 9 EPISODES
COPYRIGHTED 1914 ECLECTIC FILM CO.

Arthur Conan Doyle received deserved credit in Chapter 16, Underground Rivers in English Fiction, but we should also include him in regard to Saturday matinee movie features, The Triumph of Sherlock Holmes (1935) based on his Valley of Fear (1914) being an example.

Holmes, facing into retirement, takes on one last case to catch the elusive Dr. Moriarty and almost succeeds, but Moriarty falls into an underground river, so he could have survived.



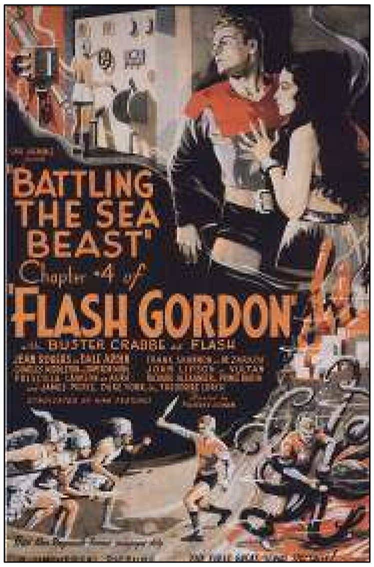
GAUMONT-BRITISH PICTURE CORPN LTD
present
ARTHUR WONTNER
in
THE TRIUMPH OF SHERLOCK HOLMES
with
LYN HARDING
LESLIE PERRINS & JANE CARR
based on
THE LATE SIR ARTHUR CONAN DOYLE'S
"VALLEY OF FEAR"
Screen Adaptation
H. FOWLER MEAR & CYRIL TWYFORD

Western Justice (1935), featuring Bob Steele as Ace, a lawman who disguises as drifter, and a cave with a secret tunnel and a good deal of mayhem. Ace dynamites open the "underground river" which the bad guys have sequestered to deny Red Fort, Arizona its water supply.

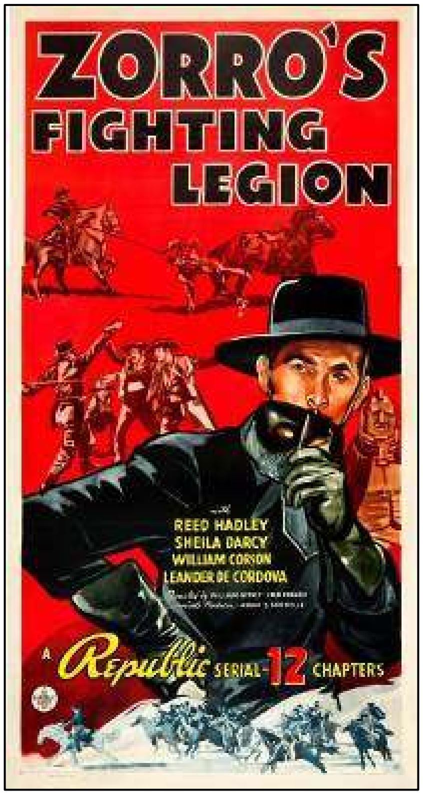
Bob sings “Desert Breeze,” a song featured in his earlier films and to be featured again.

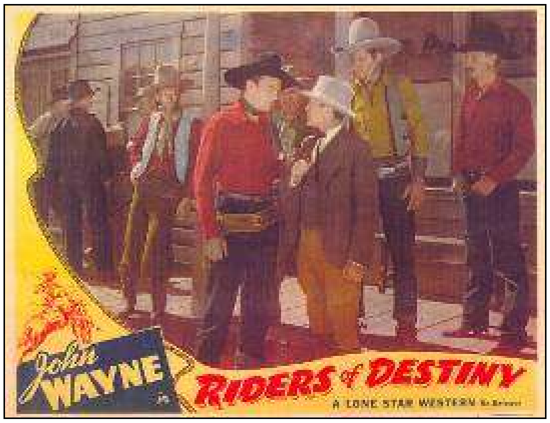
Bob Steele
"WESTERN JUSTICE"

In Chapter 3 of the 1936 movie serial of the Flash Gordon saga cited in Chapter 24, Underground Rivers in the Comics, Flash and Dale fall through a trap door into an underground river, where Flash fights with Shark Men who wear silver bathing caps even on land. As the events do not carrying forward any plot implications for the rest of the serial, the episode appears to have been inserted to get the serial's length up to the prescribed 13 chapters, and possibly to show Buster Crabbe's prowess as an Olympic swimmer.

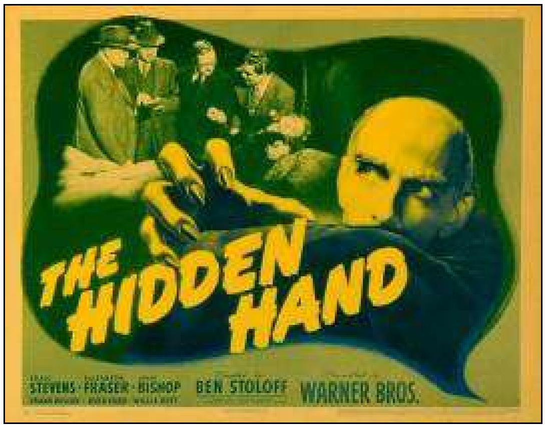


In episode 8, "Flowing Death," of Zorro's Fighting Legion (1939) serial, Zorro manages to disembark just before the runaway stage crashes into a ravine. After more close calls, Zorro enters the mountain hideout of criminal Don del Oro. To flush out the masked intruder, del Oro has his henchmen move boulders to unleash a raging underground river.


ZORRO'S
FIGHTING
LEGION
REED HADLEY
SHEILA DARCY
WILLIAM CORSON
LEANDER DE CORDOVA
A Republic SERIAL 12 CHAPTERS

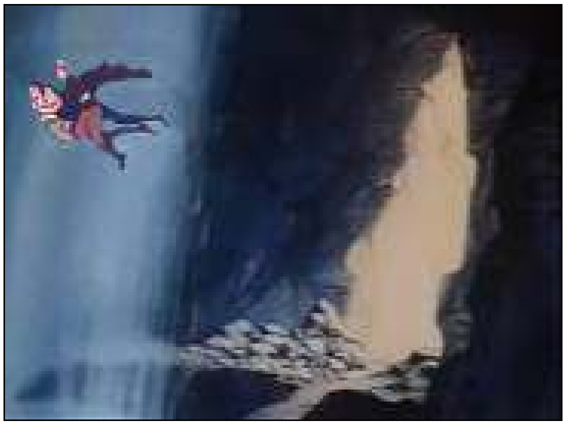

John
WAYNE
RIDERS of DESTINY
A LONE STAR WESTERN

The plot of Riders of Destiny (1933) is standard, but the stunt-work for John Wayne is noteworthy and an above-ground river is created when a well leading to an underground is dynamited.


THE HIDDEN HAND
STEVENS · FRASER · BISHOP
BEN STOLOFF
WARNER BROS.

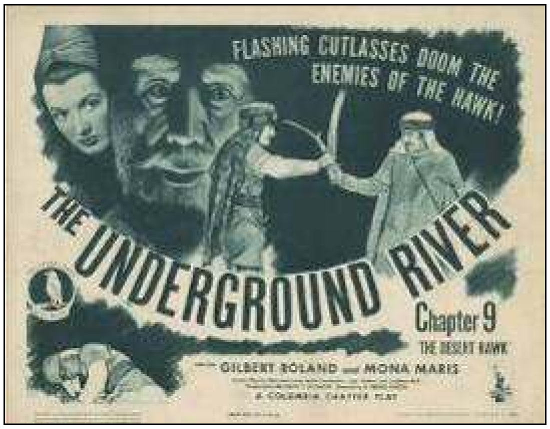
The Hidden Hand (1942)

There is the mansion, which is a maze of hidden passages, sliding panels and trapdoors. Turning the hands of the clock activates a trapdoor underneath and dumps one into an underground river.



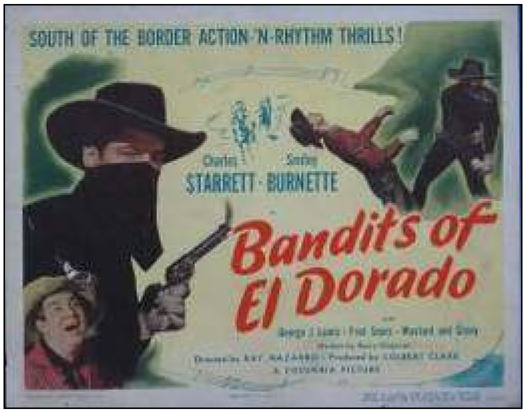
Superman and the Underground World (1943) in Technicolor.

Landing on the shore of an underground lake, Lois and Henderson lose their barge to the current and are captured by a race of cavern birdmen. Who will zoom to their rescue?


FLASHING CUTLASSES DOOM THE ENEMIES OF THE HAWK!
THE UNDERGROUND RIVER
Chapter 9
THE DESERT HAWK
GILBERT ROLAND and MONA MARIS
A COLUMBIA CHAPTER PLAY

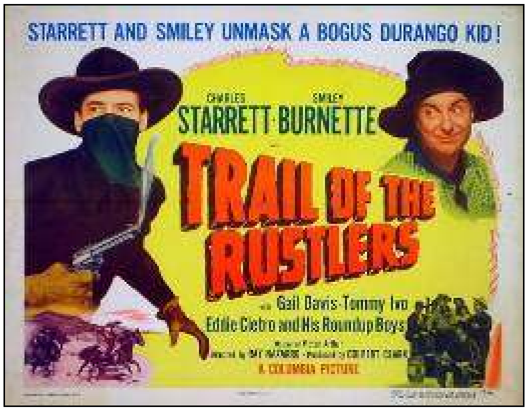
Chapter 11 of the Columbia film serial The Desert Hawk (1944), "The Underground River" in which "flashing cutlasses doom the enemies of the hawk!"

A couple of B-grade Durango Kid Westerns,


SOUTH OF THE BORDER ACTION-'N-RHYTHM THRILLS!
Charles STARRETT · Smiley BURNETTE
Bandits of El Dorado
A COLUMBIA PICTURE

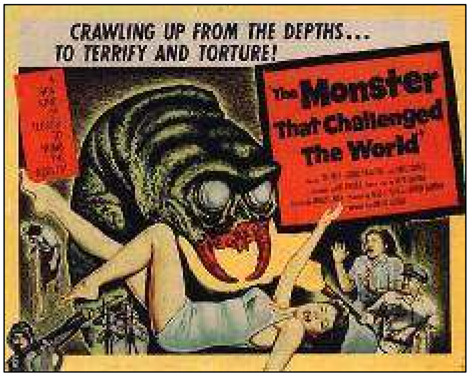
Bandits of El Dorado (1949), being a quintessential Boy's Club movie, needed only a male cast. In hunting the villains, our hero Chuck Starrett poses as one himself, shooting the forewarned Texas Ranger captain with blank cartridges. Now a "wanted killer," Chuck gains entrance to the hideout of the bad guys through a trap door into an underground river.

"Come and Get Your Dinner" is performed by Smiley Burnette with Mustard & Gravy


STARRETT AND SMILEY UNMASK A BOGUS DURANGO KID!
CHARLES STARRETT · SMILEY BURNETTE
TRAIL OF THE RUSTLERS
with Gail Davis · Tommy Ivo
Eddie Cletro and His Roundup Boys
A COLUMBIA PICTURE

Trail of the Rustlers (1950), a Durango Kid saga starring Steve Armitage, is also about bad guys (the Mahoney gang, in this case) conniving to deprive a community (residents of the Rio Perdido (Lost River) Valley) of its "underground river."

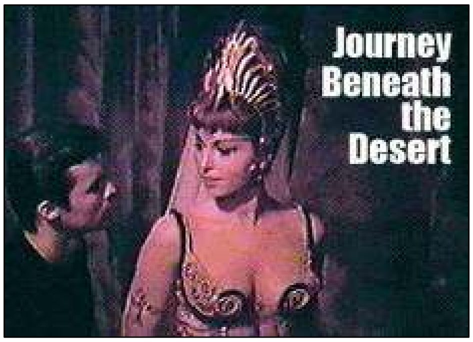
Smiley Burnette sings "Shoot Me Dead for That One" with Eddy Centro and the Roundup Boys.


CRAWLING UP FROM THE DEPTHS...
TO TERRIFY AND TORTURE!
The Monster That Challenged The World

In The Monster That Challenged the World (1957), an earthquake has led to the hatching of eggs belonging to a prehistoric giant mollusk. The hatchlings escape into an aquifer, emerge from the Salton Sea and proceed to terrorize the citizens of California's Imperial Valley.

The problem is finding them all before they escape to the ocean. The scientists must locate the underground river that leads to the slimy predators' nest.

Selections of the film's music were reused in King Kong vs. Godzilla (1962).



Journey Beneath the Desert (1961) begins with bad weather forcing a helicopter to land in an atomic testing range in the Arabian desert where the crew notices a local going over a waterfall.

When they pull him to safety, he takes them captive and leads them down to Atlantis, which turns out to have sunk into the sands of the desert, not the Atlantic. In the escape sequence, heroes battle guards and flee via an underground river. The photo suggests why Boys Clubs liked the movie.

Gone may be Saturday matinee at the Bijou, but there's the television.

In the 1974-77 TV series Land of the Lost, Rick Marshall, his son Will and daughter Holly are rafting the Grand Canyon when they are caught in an earthquake. The Colorado River dives into the earth's interior, and down the trio plunges!

The theme song,

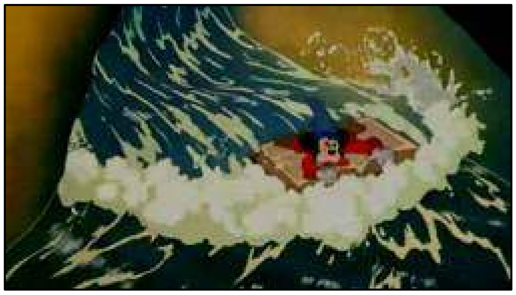
Marshall, Will, and Holly
On a routine expedition
Met the greatest earthquake ever known.
High on the rapids
It struck their tiny raft.
And plunged them down a thousand feet below.
To the Land of the Lost.
To the Land of the Lost.
To the Land of the Lost

LAND OF THE LOST

Animations

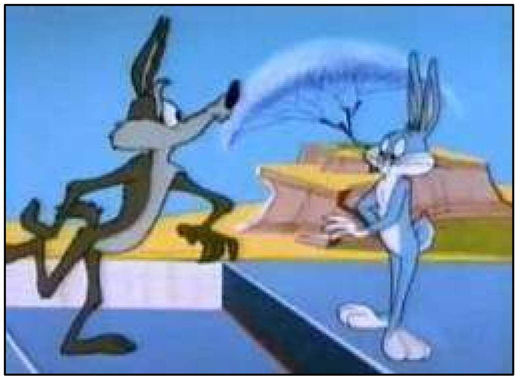
The previous chapter dealt with frame-by-frame comic strips and comic books. We'll now progress to animations.

We'll start with an animation of better quality, however, Disney's Fantasia (1940). While the Sorcerer's Apprentice setting isn't subterranean, per se, the lighting and the stairs suggest that the broom-brigade is flooding the basement. Mickey had brought upon himself an underground river.



"Hare-Breadth Hurry" (1963) opens as a typical Wile E. Coyote and Road Runner cartoon, until Bugs Bunny slows enough to reveal his identity and explain why he is in the cartoon instead of the Road Runner. In using his wits to outwit the Coyote, Bugs draws a line in the road, at which Wile stops. Bugs then draws a second line, but as Wile steps in between the marks, the bottom falls out from under that segment dropping Wile E. Coyote into an underground river and Bugs runs off.

The underground river as a gag is a metaphor not anticipated in Chapter 29.



Not derived from a book or comic strip, the Thunderbirds series is pure TV, which is to say, wasteland.

In "Terror in New York City," aired in 1965, Thunderbird 2 is inadvertently incapacitated by an experimental high-speed Navy strike vessel. When an operation to move the Empire State Building goes awry and the building collapses, the Navy allows Thunderbird 4 to hitch a ride on the same ship to find an underground river and rescue a reporter trapped beneath the wreckage.

Brian : *I've bee studying Manhattan Island, Mr. Tracy. Its base is solid rock. Underground streams do exist, but they've never been considered a threat.*

Mr. Tracy: *Does that wash out your underground river theory?*

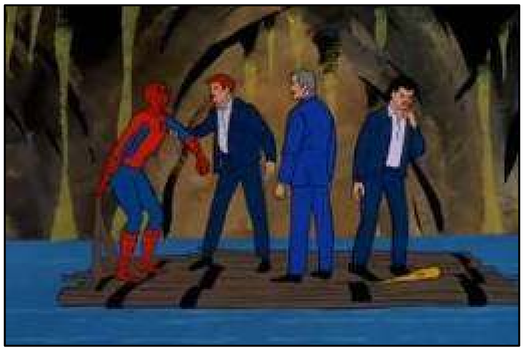
Brian: *No, it's possible that over the last hundred years, the minor streams have eaten.*

Mr. Tracy: *What are you getting at, Brian?*

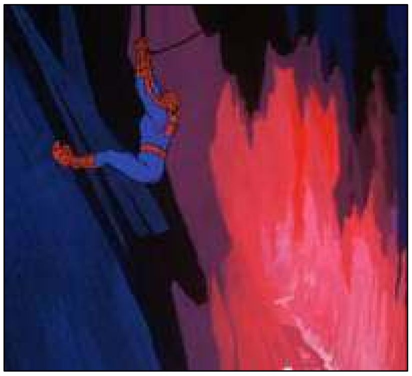
Brian: *Well, no recent surveys have been carried out. It's got to be a difficult task to locate the river.*

Mr. Tracy: *I see. Already a touch and go whether the Thunderbird 4 can arrive in time. Now the rescue* could be delayed even further!

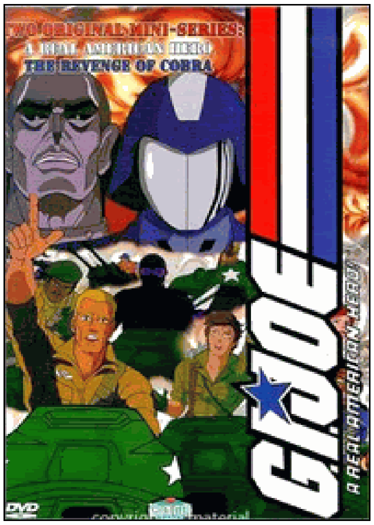
In the Spider-Man TV series (1967) "Cloud City of Gold," Peter Parker and his professor are flying over the Andes when the plane crashes. The professor, pilot and navigator all survive but there's no sign of young Parker. Just as they notice that they're trapped in a hostile jungle with menacing natives watching their every move, Spider-Man comes to the rescue. After building a raft to getting caught in a whirlpool, Spider Man leads them into an underground river. But watch out for the bats!



The Spider man episode "Menace from the Bottom of the World" is more karstic. Peter Parker investigates a seismologist's claim of detecting subterranean voices in an unknown language. Using his spider-hearing, Peter determines that these are the people responsible for a recent bank disappearance. Donning his red costume, Peter races to the next target on the evil-doers' list, sees it disappear into the ground and descends into the sinkhole to investigate.

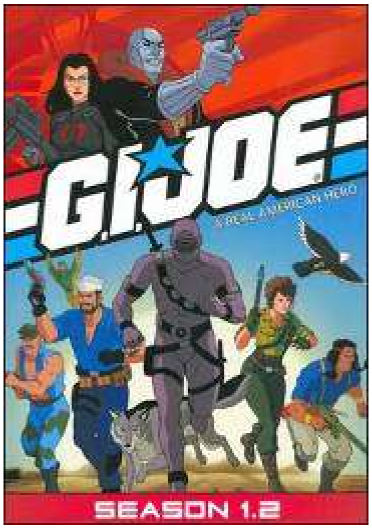


G.I. Joe's propensity for large-caliber shoulder-fired weapons is rivaled by his reliance on underground rivers. The TV covers are from DVD releases.


TWO ORIGINAL MINI-SERIES:
A REAL AMERICAN HERO
THE REVENGE OF COBRA
G.I. JOE
A REAL AMERICAN HERO
DVD

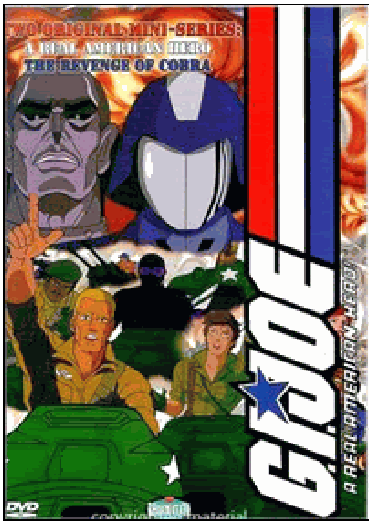
"Battle on the Roof of the World"
G.I Joe, September 13, 1984

Spirit saves Storm Shadow from drowning while escaping from an underground river. In return, Storm Shadow allows Spirit to keep the fragment of the Weather Dominator.


G.I. JOE
A REAL AMERICAN HERO
SEASON 1.2

"Cobra Soundwaves"
G.I. Joe, October 17, 1985

Trapped in a tunnel, the Joes blow a hole leading to an underground river and drift to an exit. To rescue the Sheik, they can't fly into the Cobra base, but the river runs beneath their target.


TWO ORIGINAL MINI-SERIES:
A REAL AMERICAN HERO
THE REVENGE OF COBRA
G.I. JOE
A REAL AMERICAN HERO
DVD

"Into Your Tent I Will Silently Creep"
G.I. Joe, November 20, 1986

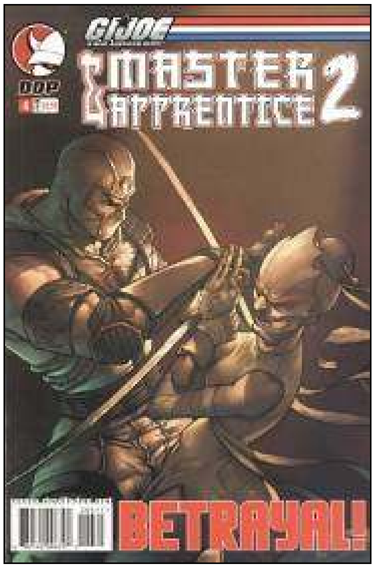
Cross Country activates a booby trap that opens a trap door, through which he falls into an underground river and is sucked into a whirlpool.

A quote from the 1984 issue: "This ain't the Tunnel of Love." -- Shipwreck and Gung-Ho before sledding into an ice tunnel. We'll cover those topics in Chapter 41, Underground Rivers in Caverns other than Karst, and Chapter 60, Amusement Parks.

G.I. JOE
A REAL AMERICAN HERO
THE BATTLE YOU DEMANDED: SNAKE-EYES VS. COBRA COMMANDER!

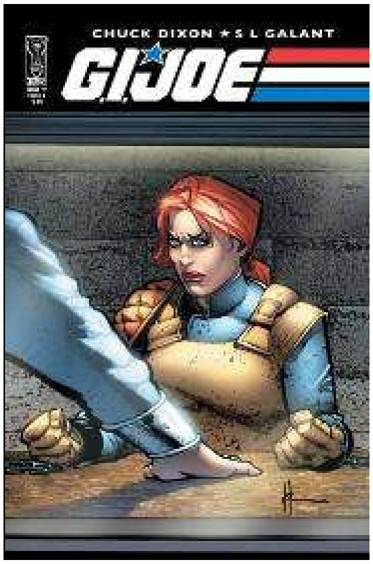
"Slam Dance in the Cyber-Castle!"
G.I. Joe #150, 1994

A brainwashed Junko Akita sowardfights Storm Shadow to the edge of a cliff, but before she strikes the fatal blow, Billy yells that she's about to kill the man she loves. She stops, but deciding that she can't live with her damaged psyche, throws herself into the underground river below.


G.I. JOE
MASTER & APPRENTICE 2
BETRAYAL!

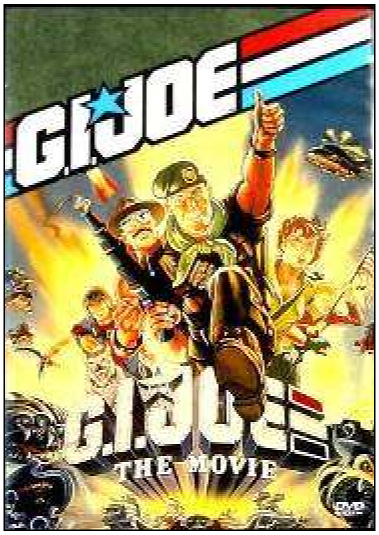
G.I. Joe: Master & Apprentice 2 #4
May 2005

The same adventure retold a decade later. As noted in Chapter 20, More Boys Club Serials, remarketing a past plot has long been standard business practice.


CHUCK DIXON ★ S L GALANT
G.I. JOE

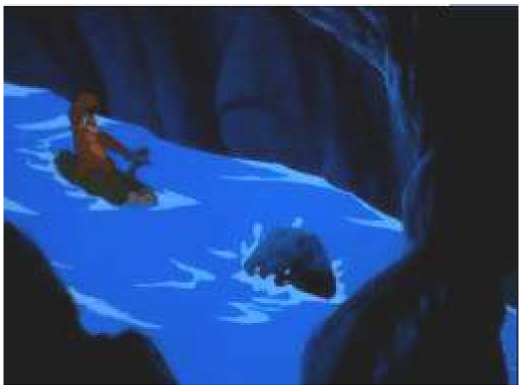
G.I. Joe #7
July 22, 2009

Shipwreck takes the mini-submarine Remora for a test run from its underground river station, but encounters trouble with the port tank. A mysterious figure jumps into the water to right the stricken sub. It's Cover Girl!


G.I. JOE
G.I. JOE
THE MOVIE
DVD

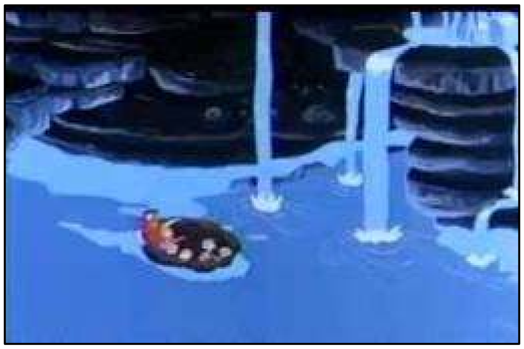
G.I. Joe: The Movie (1987), an animated film.

Tunnel Rat finally does something useful, and finds a tunnel leading to the underground river that the Drednocks are planning to seal so spores don't enter.



The 1996-97 Jungle Cubs animated series was based on the Disney feature film The Jungle Book (1967) but with youthful animal characters.

The Middle Jungle was a hidden area with only one entrance, the Cub House throne. When the snake-like leaver is pulled, the throne moves to reveal the doorway to the underground river.



In Duck Tales, The Movie, Treasure of the Lost Lamp (1990), Scrooge and lads take a wild underground river ride out of a crumbling temple. Once they're back in sunlight, one of the youngsters remarks,

> *I don't mind doing that again, now that we know we can live through it.*

To the right, Scrooge and nephews ascending Niagara Falls via a secret underground river revealed in Chapter 47, Wrecks of Ancient Life.

As to why Scrooge and nephews so often find themselves in such waterways, perhaps it's because they're themselves an active Boys Club.

Big Budget Movies

Today's entertainment industry is more opulent. Boys Clubs no longer bike to Saturday afternoon double features hosted by a local celebrity -- not infrequently titled "Captain" -- who leads them in rousing cheers. They're driven to a posh cinema complex for PG-13s. The showings may be no more entertaining than those of a simpler era, but they cost more. We'll mention a few that feature underground rivers.

Willy Wonka & the Chocolate Factory, the 1971 the film adaptation of **Roald Dahl**'s Charlie and the Chocolate Factory (1964) is a florid funhouse full of trick doors and underground rivers. Whereas Dahl's book remains a favorite of boys and girls alike, the movie was scripted with unruly boys in mind.

Wonka's chocolate river is a tunnel described by reviewers as a "psychedelic nightmare filled with screaming skippers and decapitated chickens."

As humankind nears extinction, a scientific remnant flees deep underground in City of Ember (2003) by **Jeanne DuPrau**. But their power supply is failing and it's up to three young adults to take a roller-coaster ride down the underground river, over the waterfall and when the boat stops, they see the natural world, the sky and the moon. The photo is from the 2008 movie.

Script by **David Goyer**, screenwriter for Batman Begins (2005),

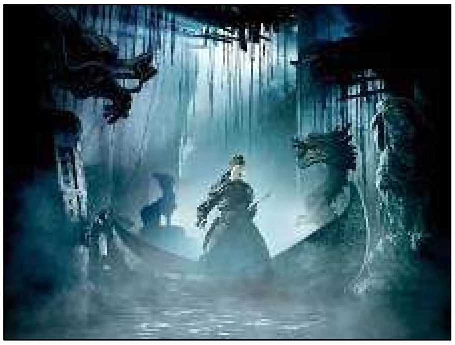
> *Wayne climbs down a jagged rock crevice. Air blows in his face. The crevice widens into a low-ceilinged chamber. Wayne hears the rush of water. He crouches, advances through the low chamber. It turns downwards, steeper. Wayne carefully slides on his back, lowering himself into limitless black.*
>
> *Wayne stands. A roar of water now. He reaches into his coat, pulls out a chemical torch, cracks it, throwing light into a vast cavern.*
>
> *An underground river, a jagged ceiling, far above, which as Wayne peers, starts to move. Bats explode from the ceiling. Thousands descend, screeching, attracted to the light. Wayne instinctively crouches, but as they sworn around him terrifyingly.*
>
> *Wayne rises to his feet amidst a cyclone of bats, watching flutter blackness with profound calm.*
>
> *And he knows the symbol he must use.*

King of California (2007) is about pursuit of a purported cache of Spanish gold buried under the L.A. suburbs. An ancient map and modern surveying equipment lead to stones on a golf course with etchings matching those recorded in a conquistador's journal. Marking off distances inside a Costco store, the searcher jackhammers into the display floor and using scuba equipment from the discount store shelves, plunges into an underground river in search of the loot.

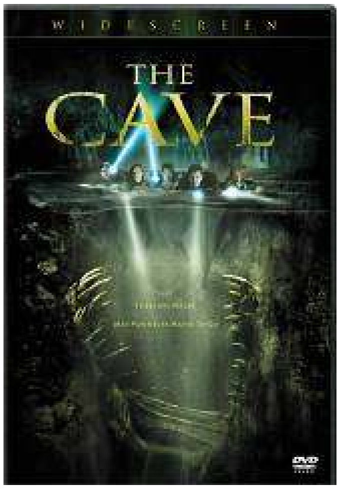
Quantum of Solace (2008), the 22nd James Bond film, Agent 007 uncovers a conspiracy to steal the Bolivian water supply. While surviving the intended land acquisition by air, Bond is shot down, but skydives into a sinkhole where he discovers the subterranean dam constructed for this evil purpose.

Detective Dee and the Mystery of the Phantom Flame (2010) features Hong Kong superstar Andy Lau as the sleuth charged with unmasking the mastermind behind a series of spontaneous human combustion murders, circa 689.

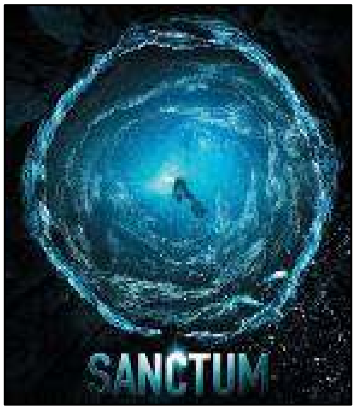
To the right, Lau ventures on an underground river,



And we have the claustrophobic movies. In The Cave (2005), underwater explorers are summoned to Romania's Carpathian Mountains to investigate a mysterious river. Cutting-edge breathing gear gets unpacked, camaraderie and budding romances develop, and then everyone becomes trapped in the depths where monsters begin to pick off the cast, one by one.



In Sanctum (2011), cave divers trapped when a portion of the cave system collapses face a life or death struggle as they seek a route through unexplored recesses of the cavern.



Sanctum opens with a promising note "inspired by true events," the story being loosely based on that of the 1988 exploration of the southern Australian Cocklebiddy 6.5-kilometer underground river system in having three sumps.

The real-life Sanctum explorers were several kilometers into the tunnels when the entrance collapsed due to rainwater accumulation. Seven explorers escaped immediately. Thirteen were trapped deep inside as water slowly filled the rock traps. Thanks to a handheld radio, those who'd escaped provided mapping support to those yet within. After a 24-hour ordeal, an alternative passageway was found and within another 6 hours, all got out safely.

Conclusion, The Underground River in Fiction

In this chapter, we've made but a small point: the entertainment industry regularly pipes underground rivers in our direction.

In the larger perspective -- ten chapters worth, actually -- we've compiled hundreds of works ranging from foundational works of modern fiction to the ephemerallity of pop culture. Thus, let us return to the question raised at the beginning.

What commonalities of literary device have we discovered in our bibliographic sojourn?

Our impressions may relate to myth (Chapter 1), metaphor (Chapter 29 ahead), psychology (Chapter 37) or our need for belief (Chapter 90), but here, perhaps like the bulk of our writers, we'll be more pedestrian. What are the repetitions?

For the fledgling author seeking a well-trod, marketable path, we suggest a few.

Fictional underground rivers tend to serve one of two purposes:

- As entry to a place of adventure, sometimes at the wish of the protagonists, sometimes (and perhaps more often) as the result of a mishap.
- As exit from the above. Deus ex Machina: a boat moored on the subterranean bank. The tale ends again in daylight.

Fictional underground rivers tend to have common attributes:

- Illumination of some sort. A tale requires an envisionable setting.
- Rapids, perhaps Class III. A plot must never drag.
- An absence of siphons (Chapter 44). Few protagonists carry air tanks.
- Stream banks suitable for disembarkation. Options for on-the-water action are limited.
- Precious stones and phototrophic vegetation. Awesome scenery over blasé.
- Hydraulic implausibilities, particularly in terms of mass and energy conservation. Where does the water end up and what makes it get there?

Fictional underground rivers tend to elicit particular emotions.

- Isolation. We're alone in a dark environment.
- Introspection. There's time to ponder.
- Fear. What omen lurks around the next bend?
- Inevitability. The tunnel's path is not of our choosing.

The list is by no means complete, but perhaps the suggestions can serve as a revisable framework as we pursue our own forms of fiction.

CHAPTER 26

SUBTERRANEAN WATER BODIES

We'll begin this chapter by noting our propensity to assume that what lies below resembles what we know above. To wit, "On the Cause of Fresh Water Springs, Fountains, &c.," American Journal of Science and Arts, July 1828, by Joseph Du Commun.

> *It seems that streams, rivulets and rivers under ground, are as numerous as on the surface of the earth, that they join together to form main streams, and that they are all directed towards the sea, where they empty at various depths, we may suppose also that there are lakes various in extent.*

Or let us quote from "The Artesian Well," Western Rural and American Stockman, February 22, 1894.

> *Creeks and rivers on the surface of the earth traverse scores and hundreds of miles. Then why not the same under the surface? That subterranean streams, some of them of large volume traverse underground channels with almost as little obstruction as on the surface has been proven beyond doubt... How numerous and of what volume subterranean rivers may be down deeper in the earth than the well auger has ever penetrated, of course we cannot now know.*

In the same vein, we cite The Earth: A Descriptive History of the Phenomena of the Life of the Globe (1872) by Elisee Reclus.

> *Like a captive, joyous at seeing the light once more, the water which shoots forth from the somber grotto of rocks sparkles in the sun, and careers along with a light murmur between its flowery banks.*
>
> *By means of these natural gulfs it is possible to reach the subterranean streams, and to give some account of their system, which is exactly like that of rivulets and rivers flowing in the open air. These streams also have their cascades, their windings, and their islands; they also erode or cover with alluvium the rocks which compose their bed, and they are subject to all the fluctuations of high and low water.*
>
> *The current gradually hollows out vast cavities, the ceilings of which fall in, and are carried away by the water almost in single grains. Where beds of hard stone oppose the flow of the rivulet, all it has done during the course of centuries has been to hew out one narrow aperture. This succession of widenings and contractions, similar to those of the valleys on the surface, forms a series of chambers, separated one from the other by partitions of rock. The water spreads widely in large cavities, then, contracting its stream, rushes through each defile as if through a sluice.*

We'll cite this eminent's geographer's perspective in a number of chapters, but we can't refrain from adding the aside that he was also poster-boy, so to speak, for the Anarchist movement in its turn-of-the century heyday.

ÉLISEE RECLUS

Anarchism

An Address

WM. WESS

Elisée Reclus, "Anarchism, An Address Delivered at South Place Institute, London," July 29, 1895

The International Library of Technology: A Series of Textbooks for Persons Engaged in the Engineering Professions and Trades or for Those Who Desire Information Concerning Them 36, 1903 notes that underground lakes and rivers have their own watersheds in the manner of lakes and rivers above.

> *Each of these underground lakes and rivers -- for these waters may possess both characters -- has no doubt its own watershed or area of absorption whence it is recruited, but the utmost uncertainty exists as to what the bounds of these areas may be. It is impossible to make gagings and surveys.*

Which is not to say that there are no differences in appearance from the upper world.

From College Physiography (1914) by Ralph Tarr and Lawrence Martin,

> *Underground rivers differ widely from surface rivers in many important respects. The underground valley is a rock-walled and rock-roofed cavern; its form and direction are irregular and unsystematic, as are its tributaries; there is little broadening by weathering; there are no floodplains and no deltas, for the sediment load is slight; and, since solution is the prime factor in the development of the underground course, the life history of the cavern valley is wholly unlike that of a surface valley.*

Drawing these thoughts together,

> The principals of hydraulics and hydrology are the same, under or upon the earth's surface.
>
> The manifestations may seem rather alike.

This chapter deals our propensity to categorize waterbodies we can't see with the same labels we use to categorize waterbodies with which we are well familiar, labels such as "river," "stream," "lake"and "sea."

We'll first deal with what's real, but because fiction's also part of our journey, then see where this takes us when to move to waterbodies of the imagination.

Terminology

Let us establish some terminology.

Water	Characteristics	Nomenclature
Liquid we might scoop in a bucket.	Appreciable velocity, substantial discharge, somewhat linear waterway, perhaps wadeable.	Underground Stream
	Appreciable velocity, minor discharge, somewhat linear, swimmable or boatable.	Underground River
	Negligible velocity, substantial surface area, somewhat circular in area, boatable.	Underground Lake
	Negligible velocity, extensive surface area, too wide to see across, tides and storms.	Underground Sea
Witin porous media	Wet sand, mud or fractured rock.	Groundwater

Magnitude is all that differentiates "underground stream" from "underground river," and "underground lake" from "underground sea." As it's an issue of perception, not physical behavior, we'll lump the first pair as "underground river" and the second as "underground lake." We'll deal with groundwater in Chapter 38, Hydrogeology.

Though there would be implications for exploration, in this chapter we'll not differentiate between water bodies having a free upper surface and those wholly confined within a conduit. An "underground river" could thus be pipe-like or it could be a channel meandering along the floor of a larger cavern.

A "cave" is a cavity in the earth large enough for a person to pass through and deep enough for total darkness. As for how many caves there are, it depends on who's doing the counting.

Caves in the United States

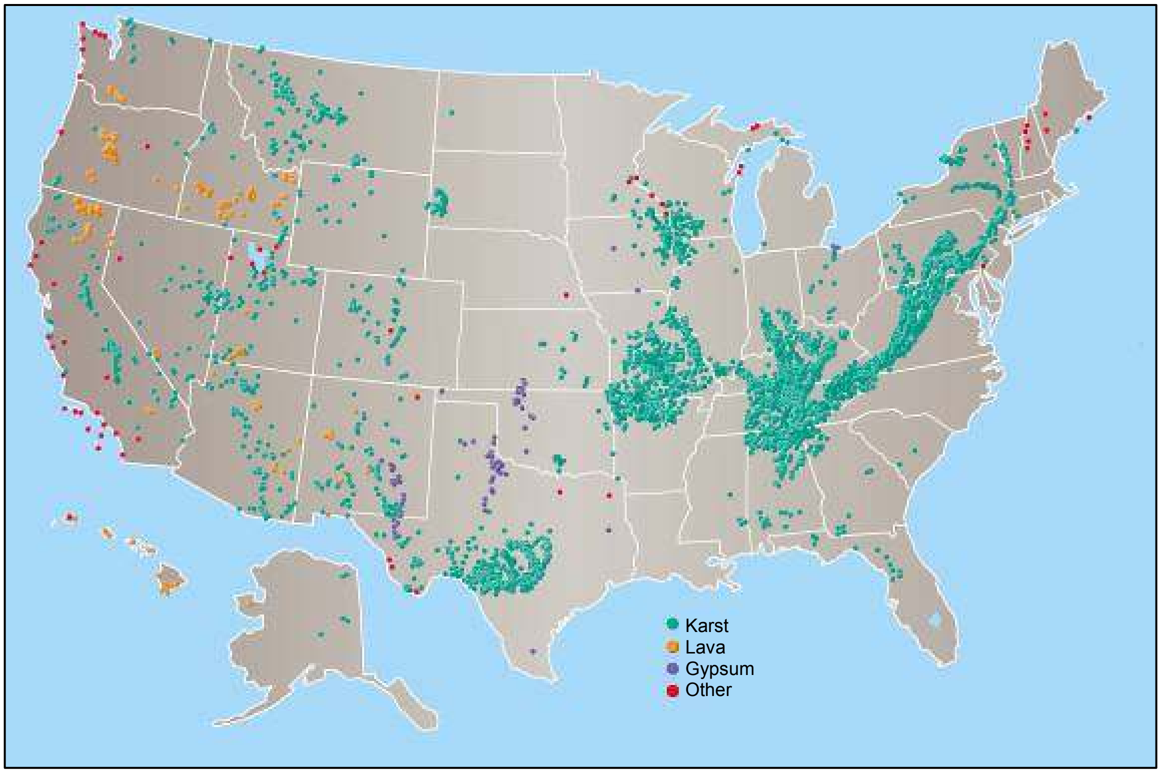
45,000	"Distribution Map of Caves and Cave Animals in the United States," Journal of Cave and Karst Studies 61:3, December 1999 by David C. Culver, Horton H. Hobbs, Mary C. Christman and Lawrence L. Master
17,000	Geology of Caves (1992) by W.E. Davies and I.M. Morgan
11,000	National Speleological Society of America

Cave density tends to increase when the count is done by state or local entities.

8,400	Caves within Tennessee
6,000	Caves within Missouri

The American cave count is a few tens-of-thousands, but beyond that, it depends on who's doing the count and how they're defining a cave.

The National Speleological Society of America map indicates where caves tend to be found.



Caves are classified as "wet" or "dry," but again it's a bit subjective. "Wet" can be taken as having ponded or flowing water. Others define "wet" as caves experiencing ongoing feature formation, which is basically to say that a drip is qualification enough. In either case, the designation may depend upon how deep a cave is penetrated; caves which first seem to be dry may evidence water in deeper recesses.

How do such cave surveys pertain to subterranean streams?

1. The vast majority of caves are the result of karstification.
2. Every karst cave is the product of flowing water, rarely with channelized characteristics in the initial stages, but increasingly likely conduited with the passage of time.
3. The vast majority of caves thus have some sort of "underground river" genesis.
4. It may be difficult to associate a conduit intercepted in well-drilling with an identifiable source or outflow. Surface features may be obscured and/or the subterranean network may be too vast. There most likely is, however, or has been, some sort of cavern involved.

"Cave River" and "Underground River" or "Cave Lake" and "Underground Lake" thus tend to be sometimes-interchanged labels.

Cave Rivers

Let us consider four alternatives of how a cave river might operate.

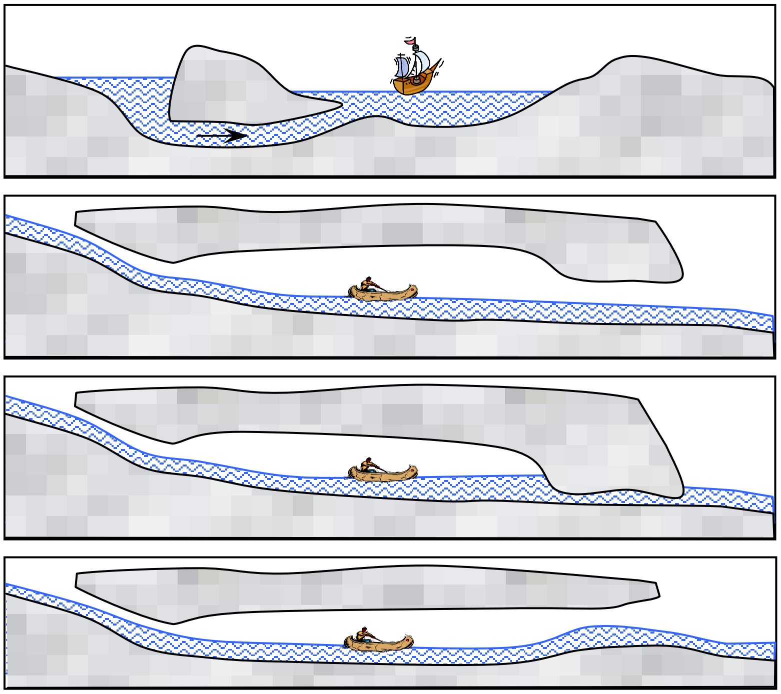
In a cave completely water filled, flow is in the direction of hydraulicx head, the combination of pressure, and elevation.

What though, if the cave's not filled?

For cave rivers, there's no problem if it's all downhill.

There's no problem with the fluid mechanics, that is, but there may be problems for the boater.

An uphill exit isn't physically impossible. Sufficiently-rapid flow can shoot up an adverse slope for a short distance, though not to the flow's initial elevation. The kayak ride would be a quick one



Chapters 16-25 contain a wealth of fictional underground rivers. Blyton's The River of Adventure runs a river into a cavern. Wright's The Hidden Tribe runs the river back to daylight.

In the real world, outflowing caves substantially outnumber inflowing ones, and through-flowing ones are rarer yet, but as we will see in chapters to follow, all three exist. All observe the same mechanical rules that govern a river that's not beneath a lid.

Fictional underground river rides tend to be through exhilarating whitewater laced with menacing boulders. To protract the plot, there are also beaches upon which to recover after close calls.

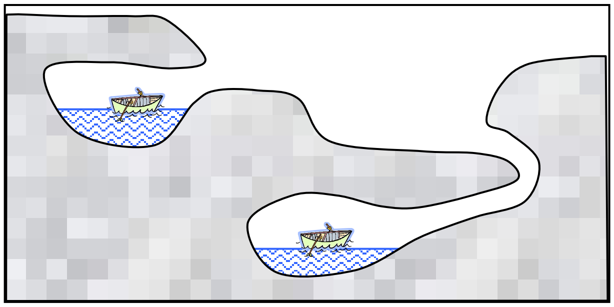
As we'll note in Chapter 39, Karstology, real-world underground rivers indeed can be steep, and as suggested the photograph of Grotte de Vallorbe, Switzerland, rough.

Cave river fiction is not totally fictional, other than the explorers always emerge.

Cave Lakes

What differentiates a "cave river" from a "cave lake?"

The distinciton tends to be one of perception: the former moves quickly and the latter moves imperceptably. But as cave waters are more often quiescent than running, it's not uncommon for a still body to be called a "river" because of its narrowness.

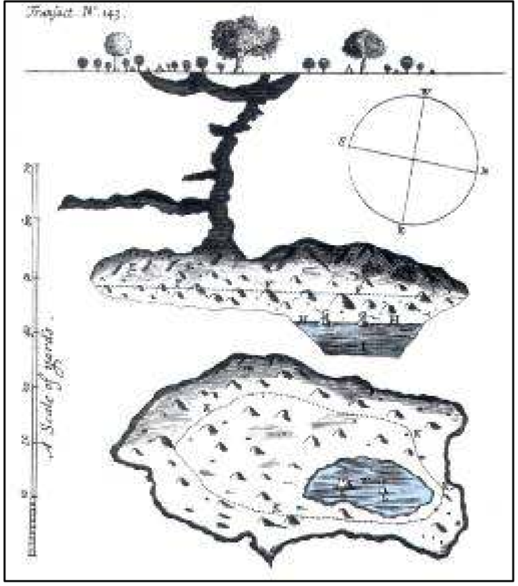


For tourist draw, "river" also sounds more exciting.

We didn't illustrate an admission booth at the cave mouths, but as noted in Chapters 51 and 52, there's often a fee for the rowboat.

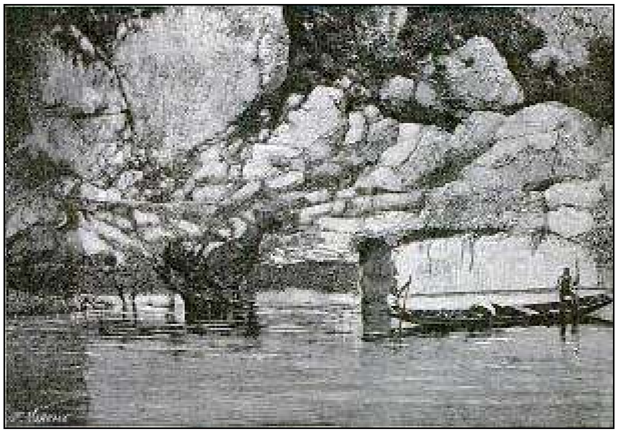
Cave lakes (as do all lakes) have one or more inflows, sometimes from the cave mouth, but more often as infiltration from above. Cave lakes likewise have one or more outflows. Those higher than the surrounding terrain can drain through the cave mouth, but most maintain water balance by seepage and evaporation. Lakes below the surrounding land surface drain through the floor to a lower water body and perhaps lose a little water by evaporation.

For an early illustration of a cave lake, we have Robert Southwell's plan and section of Pen Park Hole in Glochestershire in Philosophical Transactions of the Royal Society, 13, 1683.

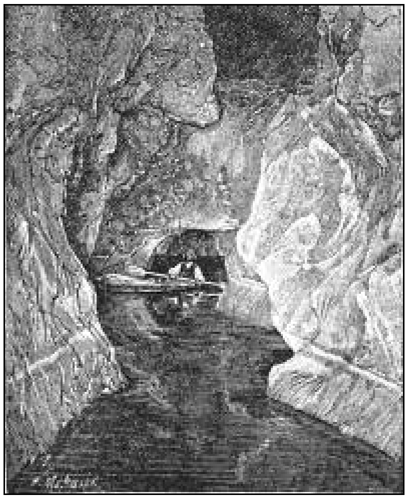


For another cave lake description, one in which the "lake" nature was a revelation, we've Paul Raymond,'s "Subterranean River Midroi" by Popular Science, June 1896, describing the French caves of the Vercors. The magazine editor must have ruled, however, that "river," with its connotation of current, made a better headline.

> *Starting to explore this river on August 28,1895, and carrying our instruments, our photographic apparatus, and our boat, the Microbe, with considerable difficulty across the slippery clay bottom, we passed into a gallery about thirteen feet long and ten feet high, contracting in some places to a few inches, which offered nothing of special interest. About one hundred and fifty yards farther on we came to a lake, where my progress had been stopped in a visit made to this place the year before. Launching the Microbe, we proceeded on our way to the unknown. We advanced between walls smooth and polished by the water upon this new Styx, which had a uniform depth of about ten feet. After a few turns the lake became narrower; an arcade, and then a second, rose before us -- the Gate of Mycenae, as we called them, standing at the entrance to the second gallery. This was the end of the lake, and for the present, of our sail.*
>
> *There exists, in effect, in the very heart of the Gausses, a considerable and eminently variable reservoir of water; it is a real lake, and through the thousand fissures, through all the meshes of this interior region, flow the waters of the plateau, sometimes by the vent of Rochemale, and sometimes, and only when rains are abundant and when the vent is not sufficient for its task, by the River Midroi.*

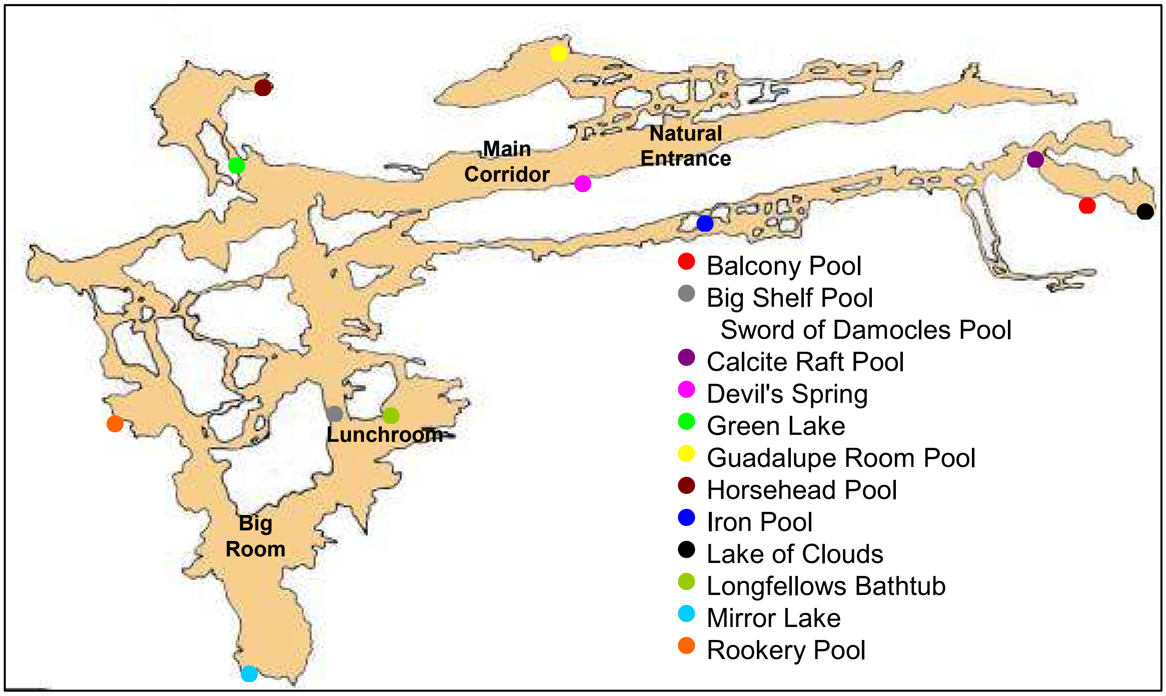


The Subterranean River Midroi



At the lower end of the "cave lake" category would be "cave pools," ponded waterbodies too small to merit "lake" designation.

New Mexico's Carlsbad Caverns National Park -- not the product of carbonic acid solutioning, but rather that of sulfuric acid -- provides an illustration of such pools. The only water in the caverns is meteoric seepage along joints, bedding planes and interconnected pores. Though some waterbodies are designated "lakes," none are more than a meter or two across.


Main Corridor
Natural Entrance
Lunchroom
Big Room
● Balcony Pool
● Big Shelf Pool
Sword of Damocles Pool
● Calcite Raft Pool
● Devil's Spring
● Green Lake
● Guadalupe Room Pool
● Horsehead Pool
● Iron Pool
● Lake of Clouds
● Longfellows Bathtub
● Mirror Lake
● Rookery Pool

Green Lake

Devil's Spring (which isn't a spring)

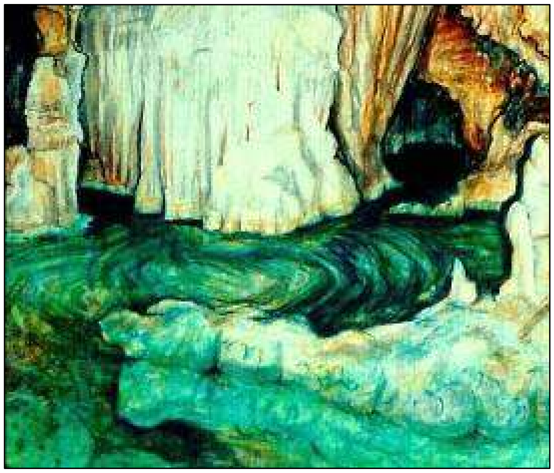
Mirror Lake

Lake of the Clouds

At the lowest point in the cavern, 300 meters below the surface, Lake of the Clouds is 3 meters deep, has no apparent drainage, and its level remains nearly constant. The regional groundwater table is some 30 meters lower.

Mean residence times estimated from bromide tracer loss range from less than a year for Rookery Pool and Devil's Spring to 16 years for Lake of the Clouds.

In the 1940s, when the military was testing the feasibility of Carlsbad Cavern as an emergency fallout shelter, Green Lake was observed for ripples caused by a nuclear bomb test hundreds of kilometers away. None appeared.



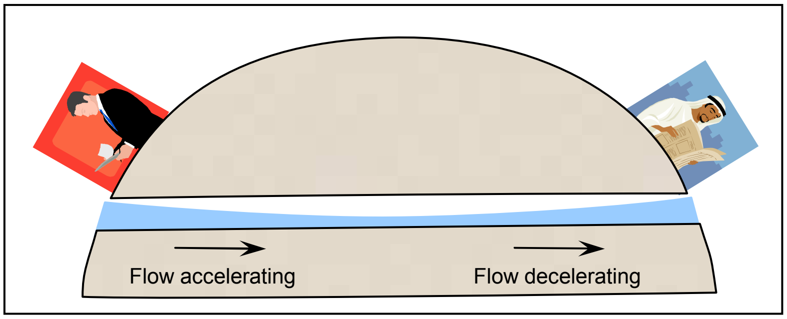
Carlsbad artwork by Kimberly Simon

The Fall of Water

A cavern extending entirely through the earth is old-hat in Boys Club fiction and likewise old-hat to physics students. To be discussed in Chapter 45, Subterranean Geophysics, the earth's interior temperature reaches several thousand degrees and the pressure approaches 300 million times greater than that on the suerface, but we'll ignore the practicality our ride..

The nearer we are to the earth's center, the smaller is the pull of gravity. If we pour frictionless water down a shaft that passes from one side of our earth to the other -- the trip's known in physics as the Graviity Express -- the water will arrive at zero velocity on the other side -- China being the proverbial destination -- in 42 minutes, having accelerated to 7900 meters/second at midpoint, a calculation communicated by Robert Hooke to Isaac Newton. Unless it's grabbed at China, the water will fall back to where we poured it and then again descend.

If we don't want to pour water to China -- Saudi Arabia may be a better market -- we can drill a tunnel accordingly and the journey will still take 42 minutes. Rather than as free fall, however, our frictionless water will flow along the side of the tunnel nearest the earth's center.

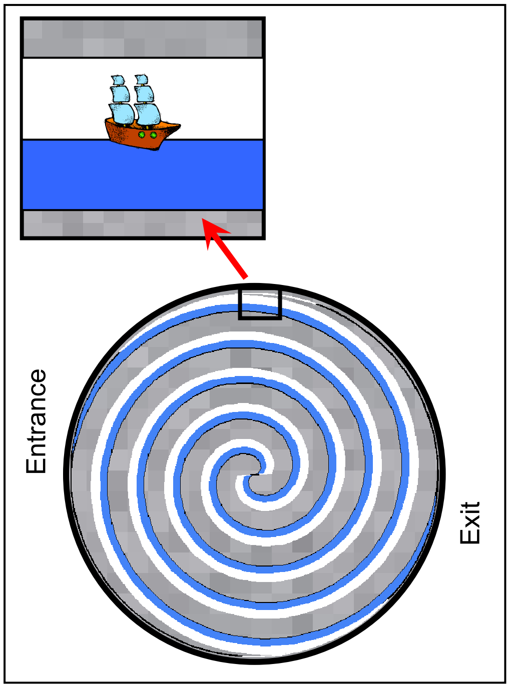


We ourselves may, of course, not wish to jump into the trans-global shaft, even with theoretical assurance that we can exit at zero velocity in the Orient.

We'd prefer to sail through the earth on an underground river. For safety's sake, we'd also prefer that the river velocity and wave characteristics not change throughout the journey. To maintain the current's downward speed as the pull of gravity dwindles, we'll thus need a steeper and steeper channel. When we head upward to the exit, we'll correspondingly want the channel slope to flatten as gravity returns.

A channel in which radial slope varies inversely with the radius will do the trick, other than at the center where the equations explode. The boatride before and after this singularity should go reasonably well.

Regarding the principal of material conservation -- we've two gravity-flowing channels and nowhere for the inflow to accumulate -- we employ the Greek philospophers' concept of the Great Abbyss.



The nearer we are to the earth's center, the less an object weighs. In some adventure fiction, vegetation at the earth's cernter grows gargantuan under the lesser gravitational pull. At the center, an object has no weight whatsoever.

Illustration from Verne's Journey to the Center of the Earth

Burroughs addresses the gravitational question in At the Earth's Core (1914). Perry, inventor of the subterranean prospecting machine speaks,

> *For two hundred and fifty miles our prospector bore us through the crust beneath our outer world. At that point it reached the center of gravity of the five-hundred-mile-thick crust. Up to that point we had been descending -- direction is, of course, merely relative. Then at the moment that our seats revolved -- the thing that made you believe that we had turned about and were speeding upward -- we passed the center of gravity and, though we did not alter the direction of our progress, yet we were in reality moving upward -- toward the surface of the inner world.*

Had Perry stopped lecturing, he'd have been close. The center of gravity of a hollow sphere's not, as he claims, half-way through its shell, but the experience of passing through a center of gravity is reasonably portrayed.

Unfortunately, Perry keeps lecturing.

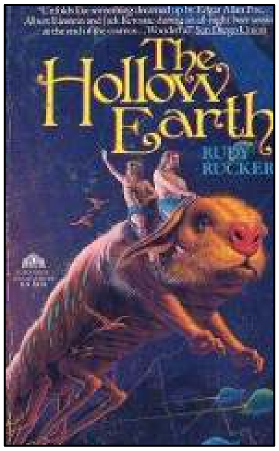
> *It is very simple, David. The earth was once a nebulous mass. It cooled, and as it cooled it shrank. At length a thin crust of solid matter formed upon its outer surface -- a sort of shell; but within it was partially molten matter and highly expanded gases. As it continued to cool, what happened? Centrifugal force burled the particles of the nebulous center toward the crust as rapidly as they approached a solid state. You have seen the same principle practically applied in the modern cream separator. Presently there was only a small super-heated core of gaseous matter remaining within a huge vacant interior left by the contraction of the cooling gases. The equal attraction of the solid crust from all directions maintained this luminous core in the exact center of the hollow globe. What remains of it is the sun you saw today -- a relatively tiny thing at the exact center of the earth.*

Perry (a la Burroughs) has been to the library, we presume, as the central sun idea, we recall from Chapter 14, dates at least back to the 1700s.

Ja, a subterranean, is a doubter.

> *That is ridiculous, since, were it true, we should fall back were we to travel far in any direction, and all the waters of Pellucidar would run to one spot and drown us. No, Pellucidar is quite flat and extends no man knows how far in all directions. At the edges, so my ancestors have reported and handed down to me, is a great wall that prevents the earth and waters from escaping over into the burning sea whereon Pellucidar floats.*
>
> *You live upon the under side of Pellucidar, and walk always with your head pointed downward?... And were I to believe that, my friend, I should indeed be mad.*

An inventor's unrestrained babble vs. a local's staid provinciality. A humorous moment in Tarzan's territory, but we don't have to delve deep into our own history to find us arguing much the same positions.



Rudy Rucker's The Hollow Earth (1990) is set in 1836. Mason Algiers Reynolds leaves his family's Virginia farm with his father's slave, a dog, and a mule. Branded a murderer, he finds sanctuary with his hero, Edgar Allan Poe, and together they embark on an extraordinary Antarctic expedition to the South Pole, the entrance to the hollow earth.

Edgar Allan Poe? The Antarctic? As we've noted in earlier chapters, the Symmes thread is well woven into American literature. Rucker's plot is hardly original, but it's a clever way to introduce a Boys Club to American history. Of interest to us, however, is Rucker's attention to fluid mechanics.

> *There were large droplets of water everywhere-some as big as peaches, some as big as pumpkins. In the moist air, they condensed like dew. But in these near-weightless conditions, the water drops were free to merge and grow to unearthly size. I drank several of the smaller ones. The bigger, head-size drops held tiny fish with stubby fins like legs. Our passage knocked the drops loose, and they slid down to merge with drops closer to the jungle's inward edge, the larger drops sliding into the sky and falling all the way to the center, there -- I supposed -- to be cooked to vapor and sent back.*

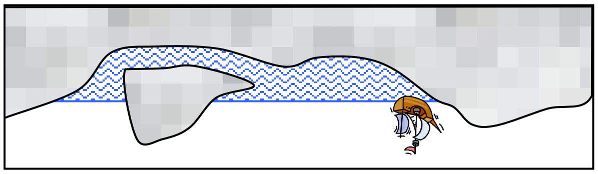
What better way to fish than to reach into the waterballs?

> *We came on the biggest waterball yet -- a monstrous trembling sphere the size of a barn, hemmed in on the upward side by vines and tendrils and cradled on the inward side by the crotch where a huge dead branch stuck out of a living tree. Peering into the water, I could make out some of those stubby-legged fish I'd seen before, only these fish were plump and a foot long. I slipped out of my clothes and pushed into the water, my new knife in one hand. The fish scattered. I swam across the waterball, stuck my head out for air, then swam back. One of the fish got right in front of me. I swam at it, trapping it against the surface, but just as I lunged with my knife, the fish jumped out of the water. I came out after it only to see the fish flopping its way up through the air, using its little finlegs to push off from every branch it passed. Maybe later it would creep back into this big glob, or maybe it would find another. Let it be.*

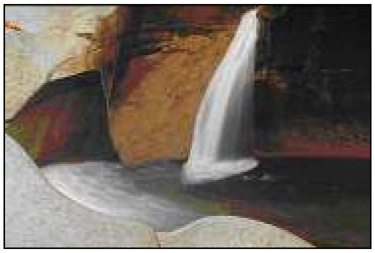
Rucker's excursion exceeding the limits of credibility notwithstanding, the author is reasonably correct (for a Boys Club author, that is) regarding waterballs. Motionless mist would indeed remain suspended in air, surface tension coalescing the droplets into larger spheres. This isn't an underground waterbody, actually, as much as it's a world of reverse bubbles, but the fishing makes good reading.

It's one thing to spin an engaging adventure for a Boys Club; it's another to pawn the model as actual science, Cyrus Teed of Chapter 14, Hollow Earth Geophysics, being a case in point.

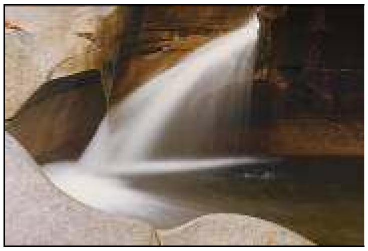
According to Teed; we're on the concave inside of a shell, our heads pointing to the center with centrifugal force thrusting us outward.



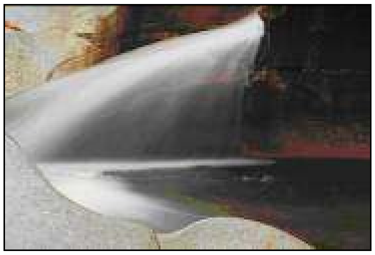
A hollow earth could indeed be twirled such that a Niagara at a particular latitude on the inner-shell cascades outward in the shape of the gravitational Niagara with which we are familiar, but an inner-earth waterfall situated at a lower latitude will fall more quickly. At the poles, the waterfall won't fall at all. The figures below suggest how a cascade of the same discharge, approach velocity and drop might appear to the hollow-earth Ecuadorians, Americans and Eskimos.



Waterfall near equator



Waterfall at mid latitude



Waterfall near pole

Waterfalls of our solid earth are inspirational, but not as awesome as if their trajectory depended on location.

Connections between the Inner and Outer Earth

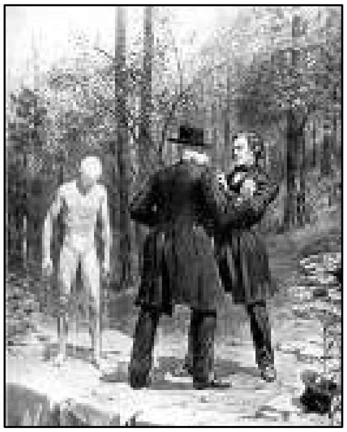
Capt. Seaborn, whom we encountered in Chapter 14, knew from Symmes where he was sailing when he passed around the verge and into the inner earth. Symzonia (1820) is thorough regarding the subterranean civilization, but not much in the way of hydrology.

> *We ascended the river, the banks of which, and all the country near them, appeared like one beautiful and highly cultivated garden, with neat low buildings scattered throughout the scene.*

The collection The Pacha of Many Tales (1835) by Frederick Marryat tells of blue-skinned descendants of Vasco da Gama, but the author also knew Greek philosophy. "Last Voyage" explains the hollow earth.

> *There is a universal balance throughout nature, and everything finds its level. There is order, when there appears disorder -- and no stream runs in one direction, without a counter stream, to restore the equilibrium.*

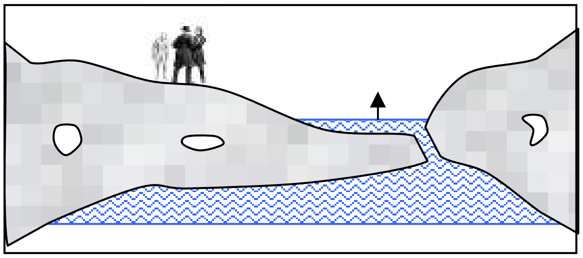
Unsatisfied as we may be with hollow-earth physics, we commend Marry for recognizing that the conservation of mass must be satisfied in any system.



John Uri Lloyd's Etidorpha (1895) documents the adventure of a man who joins a secret and nefarious society for the purpose of publishing the organization's beliefs and rituals. When he does so, the society kidnaps him, transforms him into an old man and sends him off in a 1500-kilometers/hour magnetic boat into the earth's interior.

> *I find it hard to realize that water can be so immovable. I supposed the substance before us to be a rigid material like glass, perhaps.*
>
> *There is no wind to ruffle this aqueous surface, -- why should it not be quiescent? This is the only perfectly smooth sheet of water that yon have ever seen. It is in absolute rest, and thus appears a rigid level plane.*
>
> *The surface of this lake lies as a mirror beneath both the ocean and the land. The force effect that preserves the configuration of the ocean preserves the form of this also, but influences it to a less extent, and the two surfaces lie nearly parallel with each other, this one being one hundred and fifty miles beneath the surface of the earth. The shell of the earth above us is honeycombed by caverns in some places, in others it is compact, and yet, in most places, is impervious to water. At the farther extremity of the lake, a stratum of porous material extends through the space intervening between the bottom of the ocean and this lake. By capillary*

attraction, assisted by gravitation, part of the water of the ocean is being transferred through this stratum to the underground cavity. The lake is slowly rising.



At this remark I interrupted him, "You say the water in the ocean is being slowly transferred down to this underground lake less by gravity than by capillarity."

"No," he replied; "I am telling you the truth. Have you never heard of what men call artesian wells?"

"Yes, and" (here I attempted in turn to become sarcastic) "have you never learned that they are caused by water flowing into crevices in uplands where layers of stone or clay strata separated by sand or gravel slant upward. The water conducted thence by these channels afterwards springs up in the valleys to which it has been carried by means of the crevices in these strata, but it never rises above its source."

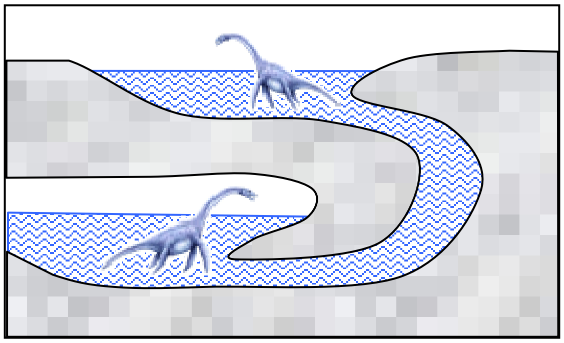
To my surprise he answered,

"This is another of man's scientific speculations, based on some facts, it is true, and now and then correct, but not invariably. The water of an artesian well on an elevated plane may flow into the earth from a creek, pond, or river, that is lower than the mouth of the well it feeds, and still it may spout into the air from either a near or distant elevation that is higher than its source."

Lloyd's artesian well works as shown to the right; the water wheel we've added to profit from perpetual motion. We met the capillary subterranean engine hypothesis in Chapter 10. Capillary force can indeed draw water somewhat above the hydrostatic surface, but can not expel water from the tube's upper end.

We needn't worry, however, as "This is another of man's scientific speculations, based on some facts, it is true, and now and then correct, but not invariably"

"Etidorhpa" is “Aphrodite” spelled backwards. But why would the goddess Aphrodite (Venus to the Romans) allow her name to be reversed? Perhaps, we speculate, because the underground river itself flows backwards?

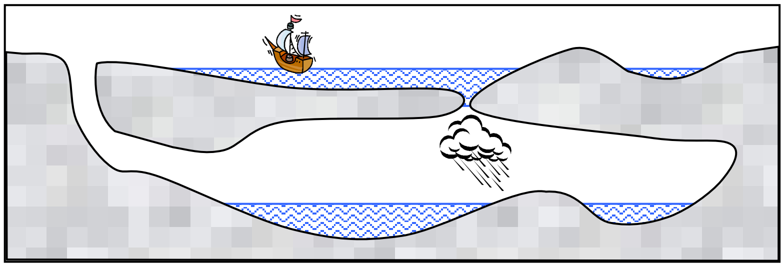


In "Dick and Dr. Dan, or The Boy Monster Hunters of the Bad Lands," Happy Days, March-May 1900, Dick, Charles and a Native American called Dr. Dan encounter plesioauri in Wyoming. But where do the creatures come from?

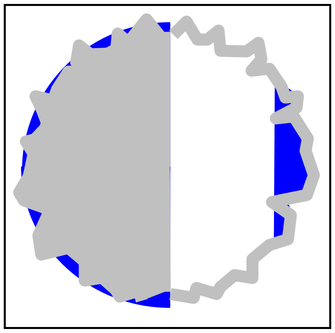
From lake connected by an underground river to a greater lake under the earth!

Dinosaur appearances twice save the two from the hands of sinister Martin Mudd, but why the Wyoming lake doesn't drain is never explained. As we will note in Chapter 63, Wyoming groundwater law is more sensible than that of other western states, but apparently the same can't be said for the state's physics.

Precipitation might reach the lower world through a leak in the roof. We include a tunnel for verification.



Subterranean Seas



Chapters 16-25 include a variety of interior seas. Later in this chapter we'll introduce the idea of contrapositionality, but now we need only to note that these interior water bodies sprawl about their fictional worlds much as do the seven seas in our own.

The diagram's left semicircle shows waters arbitrarily distributed on a gravitational sphere. Within the spinning hollow sphere on the right, islands align about at a single latitude, north and south.

We need not opine regarding the effect of lunar gravity on an underground sea, as we're provided detailed information in William A. Taylor's Intermere (1901). A shipwreck survivor is carried to the ancient country under the Antarctic where he's instructed in technology, economics, government including term limits, equal distribution of wealth, and motivation for scientific advancement.

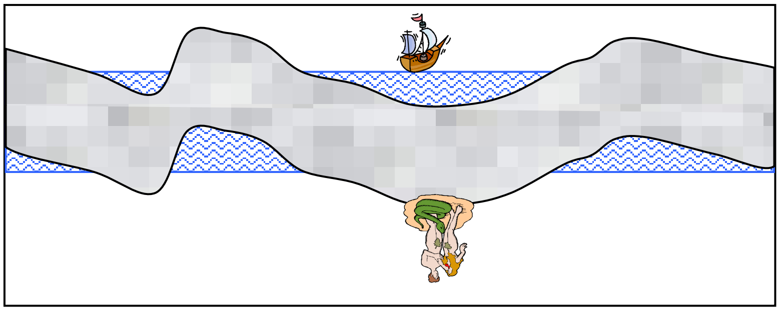
More to our interests, however, is the subterranean sea.

> *Many rivers, limpid and sparkling, coming through level and spreading valleys, and from almost every point, contribute their waters to the mere.*
>
> *The current of the mere is phenomenal -- not violent, but distinctively marked. Twice within every twenty-tour hours it sweeps entirely around the oval, affecting one-half of the mere as it moves. With the early hours of the morning and evening it sweeps from north to south throughout the eastern, and with noon and midnight though the western half of the sea.*
>
> *This current may be described as anti- or trans-tidal; that is, the general water level falls or is lowered on the side where the current runs, and rises correspondingly in the opposite half.*
>
> *The effect is this: From 6 a.m. to 12 noon and from 6 p.m. to midnight, throughout the eastern half, the tide runs in from those rivers falling in from the east, and correspondingly rises and moves inland in those failing in from the west, and then the current flows north on the western side from 12 noon to 6 p.m. and from midnight to 6 a.m., so that for half the time the rivers on either side ebb or flow into the sea, and for the other twelve hours rise and !low to the interior, east or west as the case may be.*
>
> *The effect of this is singular indeed, or it was to me. The rivers appear to run inland from the sea a part of the time, and then run from the landward into the sea for twelve hours, or an equal period, while the sea itself appears to be a subdivided river forever flowing in an elongated circle along the opposite shores.*

As the observer concedes, the phenomenon is rather "singular."

Contrapositioned vs. Non-Contrapositioned Topography

In an inner world hydrographically contrapositioned to our own, our land lies above its waters and their waters, below our land.



William Miller envisioned a contrapositioned variation of the Symmes model in The Sovereign Guide, A Tale of Eden (1898).

> *The inner Eden is inhabited by various peoples spread out in continents that correspond in placement to the seas of the outer world.*

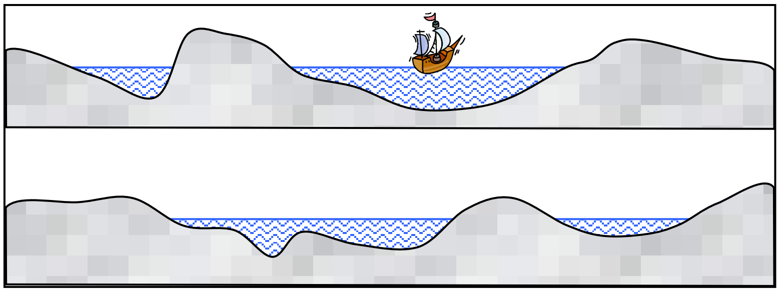
Eden yet exists on the underside, though overgrown, as does the tomb of Adam and Eve. Unfortunately for biblical archeologists, those sites are under our oceans.

For geographies on either side of a shell to be contrapositioned, the shell's thickness must be the same everywhere, one side dipping where the other humps.

Muddock's The Sunless City (Chapter 21) describes contrapositionality as Flin pilots his submarine into a bottomless lake and through a hole lined with gold.

> *It is a well-known fact, ladies and gentlemen, that we live upon a globe; that is, on the external crust of a huge ball. There is one thing which science has proved beyond all doubt, and that is, that this ball is not solid but hollow... and I say that in the centre of the earth are subterranean rivers and buried seas.*
>
> *By the light of science it has further been revealed to us that the crust of the earth upon which we stand in no part attains a greater thickness than fifteen miles; and it is stated as a scientific truth that if we could dig down to that depth, and break through the inner surface of the crust, we should come to fire. I assert that that is a monstrously absurd theory; that we should do nothing of the kind, but that we should break in upon a new world, a new race of beings. That we should find a land of beauty and fertility; that we should find rivers, seas, mountains and valleys. The inequalities of the bottoms of our valleys will form mountains there; and our mountains will be their seas. Like unto a pudding-mould, whereon the fruit and flowers are convex on one side and concave on the other.*

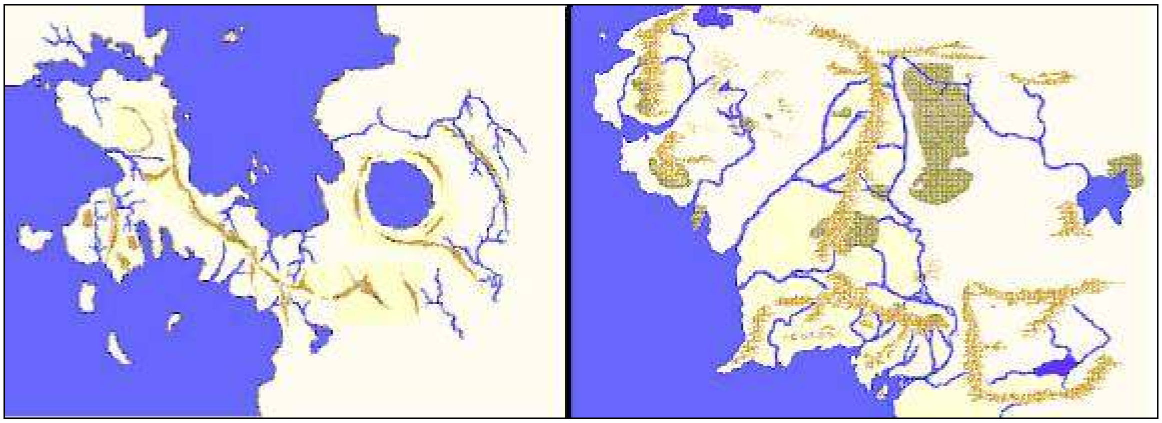
We thus could call this model the "Pudding Mold Layout." Lining the hole with gold seems excessive, but we'll give it more thought in Chapter 80, Underground Rivers of Gold.



By "non-contrapositioned topography," we mean that the underground topography bears no correspondence to the landforms above.

As Gardner arbitrarily painted the interior of his patented hollow globe (Chapter 14), it was non-contrapositioned.

Burroughs and Tolkien strove to preserve subterranean geographies from novel to novel. The hydrologic maps of Pellucidar and the Middle Earth are derived from the respective sagas.



Of hydrogeographic interest is the similarities. Both include enclosed basins. The circular water body in Pellucidar is the Polar Sea. Tolkien's world has two inland seas, the Rhun and the Nurnen. Both sagas are set on peninsulas transected by mountain ranges, barriers to be crossed by the heroes. Both worlds are endowed by multiple rivers which provide a means of transport when the characters need to move along.

Tolkien's imaginary world is clearly non-contrapositioned to ours. With Burroughs, the evidence is inconsistent. Maps derived from Burroughs' series -- there being several -- suggest no geographical correspondence between Pellucidar and our own earth, but the author explicitly wrote with a contrapositioned scheme in mind.

At the Earth's Core (1914)

> *"Look," he cried, pointing to it, "this is evidently water, and all this land. Do you notice the general configuration of the two areas? Where the oceans are upon the outer crust, is land here. These relatively small areas of ocean follow the general lines of the continents of the outer world."*
>
> *"We know that the crust of the globe is 500 miles in thickness; then the inside diameter of Pellucidar must be 7,000 miles, and the superficial area 165,480,000 square miles. Three-fourths of this is land. Think of it! A land area of 124,110,000 square miles! Our own world contains but 53,000,000 square miles of land, the balance of its surface being covered by water."*

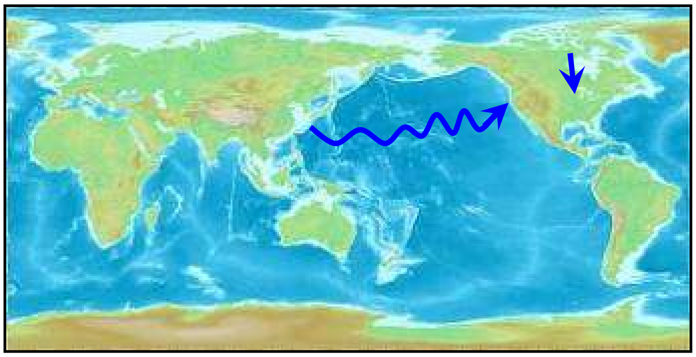
Tarzan at the Earth's Core (1929)

> *When one considers that these land and water areas upon the surface of Pellucidar are in opposite relationship to the same areas upon the outer crust, some slight conception of the vast extent of this mighty world within a world may be dreamed.*
>
> *The land area of the outer world comprises some 53,000,000 square miles or one-quarter of the total area of the earth's surface; while within Pellucidar three-quarters of the surface is land, so that jungle, mountain, forest and plain stretch interminably over 124,110,000 square miles; nor are the oceans with their area of 41,370,000 square miles of any mean or niggardly extent.*

Emerson's The Smoky God implies that the inner- and outer-world are reversed, at least in the proportion of land to sea.

> *About three-fourths of the "inner" surface of the earth is land and about one-fourth water. There are numerous rivers of tremendous size, some flowing in a northerly direction and others southerly. Some of these rivers are thirty miles in width, and it is out of these vast waterways, at the extreme northern and southern parts of the "inside" surface of the earth, in regions where low temperatures are experienced, that fresh-water icebergs are formed.*

The "three-fourths" should actually be seven-tenths, but that's minor.



Contrapositioned topography does not imply contrapositioned rivers. The greatest river of a world contrapositioned to ours would drain that sphere's Pacific continent eastward from mountains paralleling our upper-world Mariana trench.

Our Mississippi would appear as a minor embossed ridge along the bed of the subterranean American sea.

Conclusions

No geophysical theory or literary fantasy of subterranean adventure seems to be without water. We can't conceive of an interior world that's dry. We'll explore the "why?" of this in Chapter 90, Why Do We Believe What We Believe?

Let us summarize the myriad of subterranean water body possibilities we've seen proposed.

1. Underground waters could be in an ordinary cave, on the inner side of the earth's shell or even on an inner globe.
2. The behavior of underground water might mimic that with which we are familiar, could be different in issues of scale, e.g. fall faster or slower, or could behave in bizarre fashion.

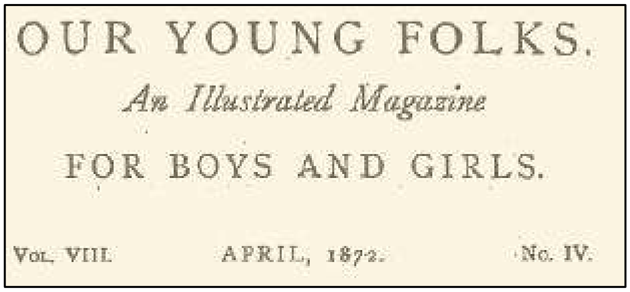
We've no paucity of possibilities to ponder.

CHAPTER 27

VIRTUALIZING THE IMAGINED: UNDERGROUND RIVEERS IN GAMES

We will begin our look at underground river games with an example of how things have changed.

Find the hidden words in the April 1872 Our Young Folks, An Illustrated Magazine for Boys and Girls entertainment.



OUR YOUNG FOLKS.

An Illustrated Magazine

FOR BOYS AND GIRLS.

VOL. VIII. APRIL, 1872. No. IV.

Underground Rivers. Two rivers flow under the first sentence and one in each of the others.

1. *They do not speak Portuguese in England.*
2. *I like to eat ham, especially with eggs.*
3. *In no part of China is tea not sold.*
4. *Pride everywhere falls to the ground.*
5. *Alum is sour, I think, and disagreeable.*
6. *They make vinegar on neglected floors in France.*
7. *I hate to drum. I am inveterately opposed to noise.*
8. *In Latin we easily write egomet or ego; not so easily in Greek.*
9. *Grindstones are at par, hones far dearer.*
10. *There in a barn on a steep, high hill.*
11. *They brought myrrh in each hand, and spice, and frankincense.*
12. *We had our own carriage the evening.*
13. *He is, with heart, hands, and pens a co-labor with me.*

Though titled "Underground Rivers," this game might not play well today, if for no other reason than that modern boys and girls have little knowledge of geography.

The answers:

1. Don, Seine
2. Thames
3. Oporto
4. Dee
5. Missouri
6. Garonne
7. Miami
8. Oregon
9. Rhone
10. Arno
11. Rhine
12. Douro
13. Pensacola

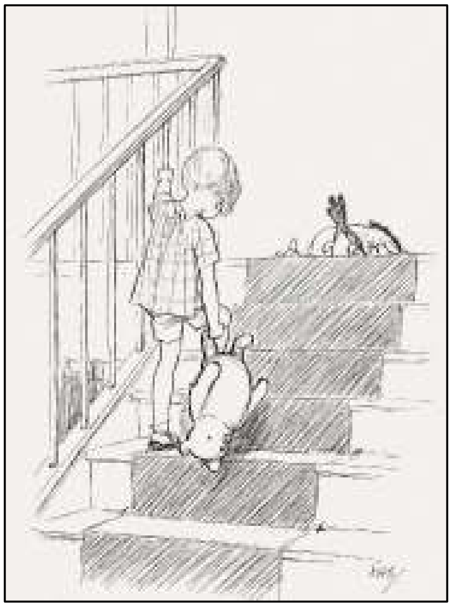
which leads us to admit that today's adults also don't have that much knowledge.

So we'll not dwell on word games, but more on to board games.

From the author of Winnie-the-Pooh., A.A. Milne, in his collection of essays, If I May (1921),

> *Just before the war I came across the ideal game. I forget what it was called, unless it was some such name as "The Prince's Quest." Six princes, suitably colored, set out to win the hand of the beautiful princess... The Blue Prince, who is now leading, approaches the ninety-sixth milestone. He is, indeed, at the ninety-fifth. A breathless moment as he shakes the die. Will he? He does. He throws a one, reaches the ninety-sixth milestone, topples headlong into the underground river, and is swept back to the starting-point again*

It's something for an Edwardian parlor, perhaps.



Below are results from Reading at Risk, A Survey of Literary Reading in America, Research Division Report #46, National Endowment for the Arts (2004).

Trends in Book and Literary Reading, Percentage by Group

Age	1982	1992	2002
18-24	59.8	53.3	42.8

According to the 2008 Pew Internet Project's Teens, Video Games, and Civics, 99 percent of boys and 94 percent of girls play video games. Younger teen boys are the most likely to play games. Boys play more often than girls, but 35 percent of daily gamers are female.

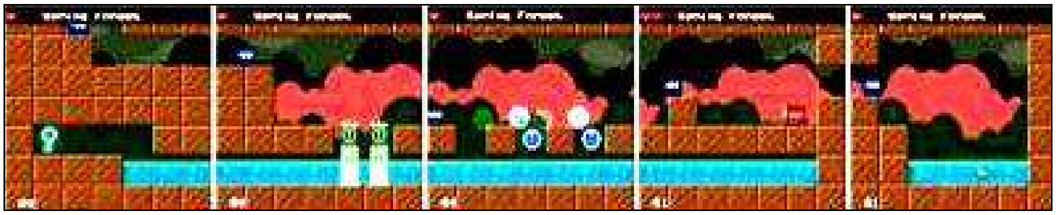
The once-readers of the works in Chapters 16 and 17, or even 19-23, are today playing video games.

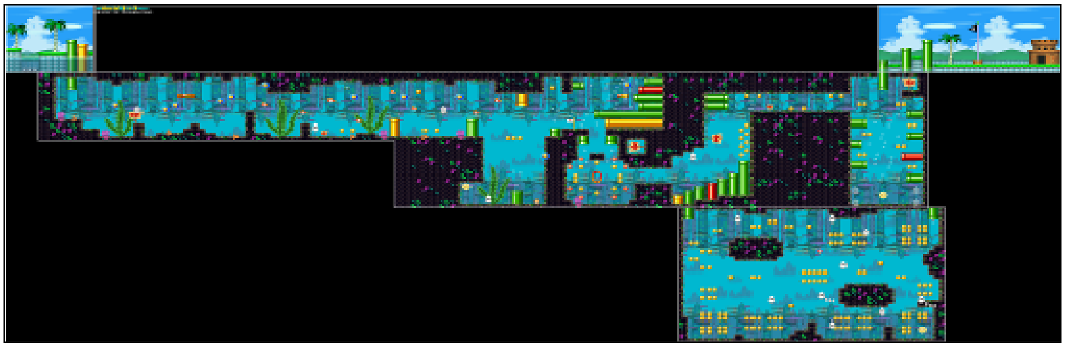
The Games We Play Today

Unlike previous chapters dealing with literature and the arts, this chapter is about the present where we invent virtual worlds to make seem real that which we've only imagined.

We will begin with a few early video games, the type in which the layout was that of a vertical plane in which the character moved to the left or right and up or down. As screenshots vary with hardware platform and edition, we make no pretense of showing the latest release of our examples. It's a fluid business in a rapid-fire universe.

The collaged screenshots from King's Quest (top) and Super Mario (bottom) illustrate how easily an underground river can be incorporated into a virtual world.





The player needs an entrance and, if he or she survives the subterranean waters, an exit.

The screenshots below are other examples.

Save the Underground River

4000
ACTIVISION

Save the Underground River is keyboard-driven.
← Space - Attack
↑ Z - Next Weapon
→ Shift - Defend
↓ X - Next Tool
C - Jetpack

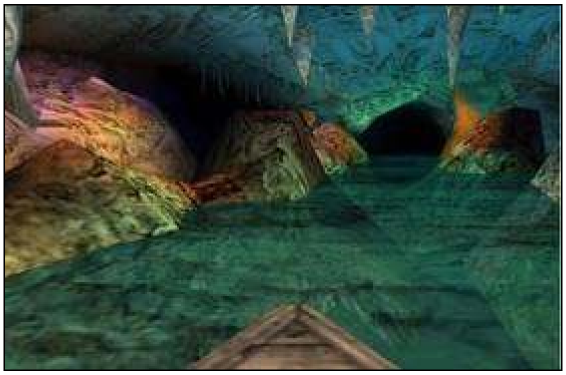
The star of the Pitfall, an Indiana Jones-style character descends into the riverine catacombs.

The next three screenshots illustrate underground rivers depicted in video games seen in the player's field of vision, nose-center.

88
AMMO
100%
HEALTH
2 3 4
5 6 7
ARMS
0%
ARMOR
BULL 88/200
SHEL 0/50
ROKT 0/50
CELL 0/300

Doom specializes in shootouts, this one across an underground river.

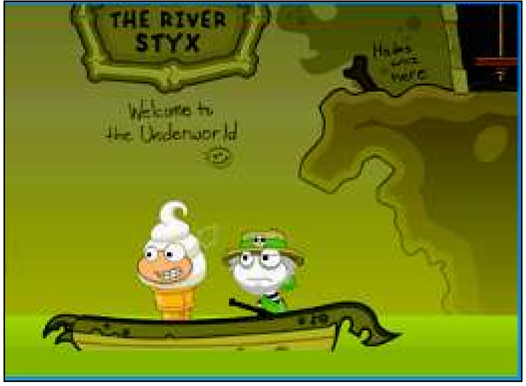
Hexen is based on Doom. Three humans, the Fighter, the Cleric, and the Mage, seek vengeance against the Serpent Rider. Hexen's underground river is shown above.

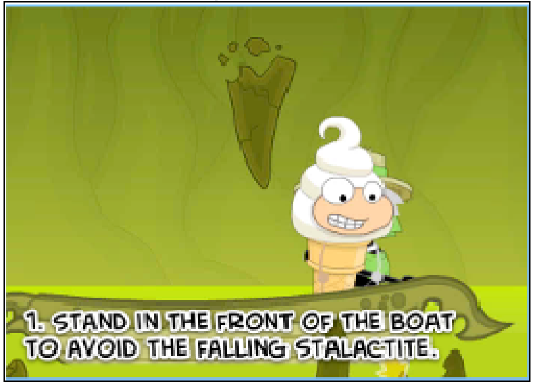


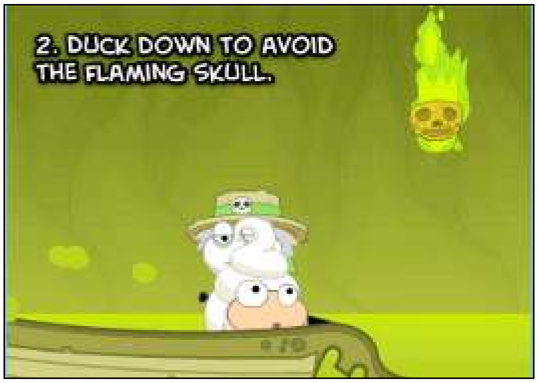
Timeline, a video game based on Michael Crichton's novel, features dungeons, great halls of French castles, jousting tournaments and of course an underground rivers.

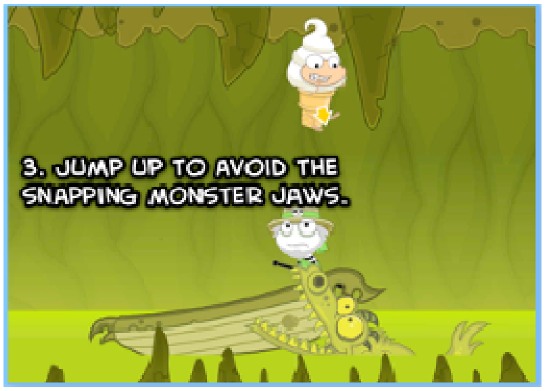
The twelfth main island to be released on Poptropica is Mythology Island.

> *How to Cross the River Styx in Mythology Island*
>
> *The answer to that is to stand right where Charon is. Then, all you need to do is avoid the flaming skulls by ducking down and the snapping monster jaws by jumping up. It's really that easy because if you're standing in this spot you'll be in a perfect position to avoid the falling stalactites as well. Trust the guy piloting the boat to know the best place to stand!*


THE RIVER STYX
Hades was here
Welcome to the Underworld


1. STAND IN THE FRONT OF THE BOAT TO AVOID THE FALLING STALACTITE.

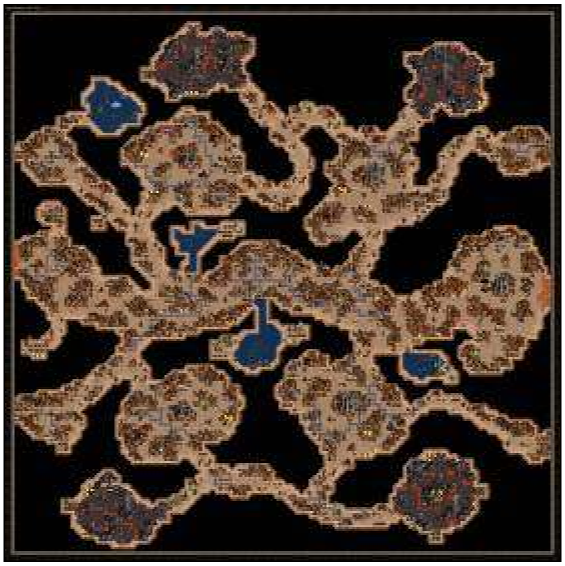

2. DUCK DOWN TO AVOID THE FLAMING SKULL.


3. JUMP UP TO AVOID THE SNAPPING MONSTER JAWS.

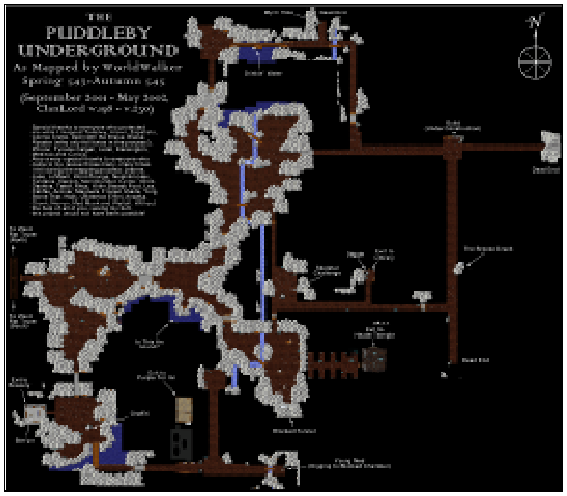
Many video games can be thought of as board games in which boards are stacked one above each other, vertical tunnels being routes. A virtual river can thus be more dimensional than its counterpart on the surface.

For the virtual adventurer, such a watercourse can facilitate exploration, but then again, it can make it more dangerous. Monopoly marches around the square, never shoots underneath. Clue at least had two secret passages.

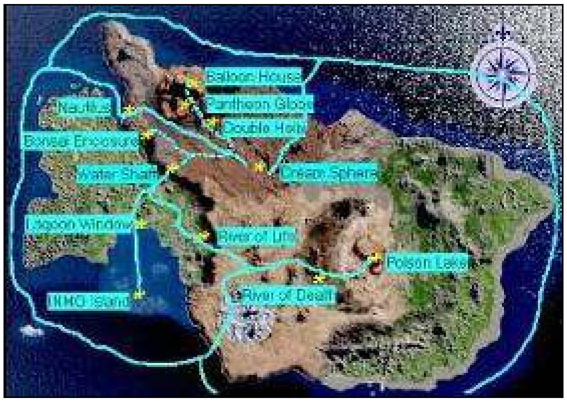
Winning requires mastering the map, most often by trial and error. Shown below are underground river layouts.



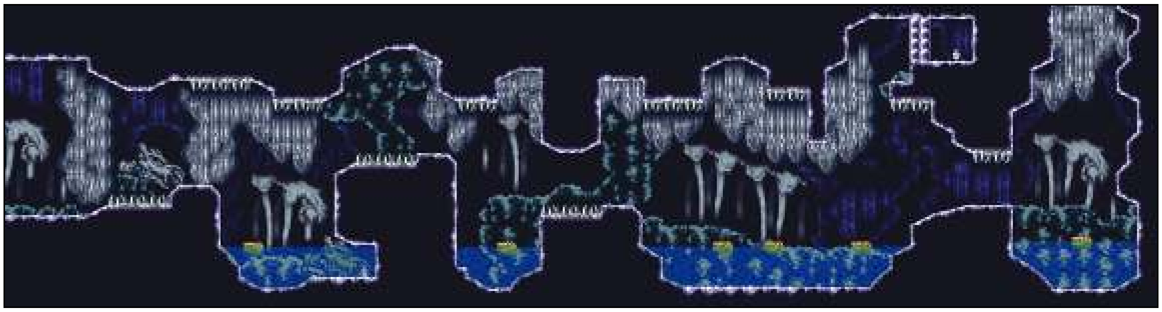
A Heroes of Might and Magic layer of tunnels, underground waters and troglodytes.


THE
PUDDLEBY
UNDERGROUND
As Mapped by WorldWalker

The Puddleby Underground of Clan Lord is consists of "snells," several of which are connected by an underground river which pools in two underground lakes.

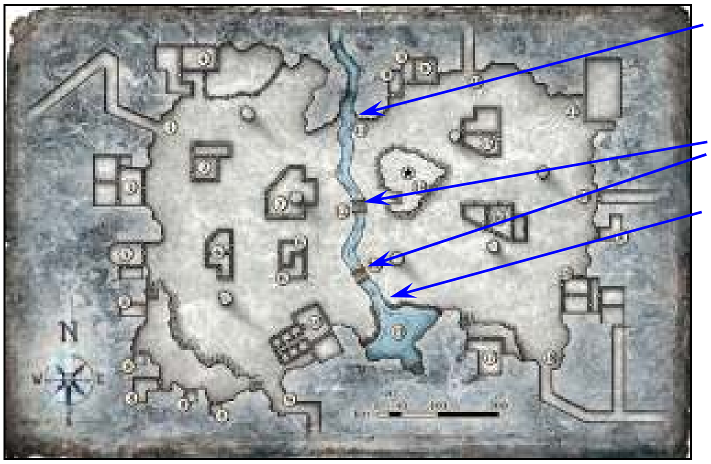

Balloon House
Pantheon Globe
Double Helix
Nautilus
Bonsai Enclosure
Water Shaft
Dream Sphere
Lagoon Window
River of Life
Poison Lake
River of Death
NEMO Island

Nemo's Mind is for Jules Verne devotees. The two underground waterways to the Dream Sphere are accessed by Mini-Sub Dolphins at high tide; at any other time the river spills out of the cliff rift just above the ocean.



This collage from Demon's Crest maps a limestone cave, complete with water on the floor. Chapter 39, Karstology, will explain why such a map isn't totally imaginary.

Myth-Weavers contains the mighty Seven-Pillared Hall, once the market square of the ancient under-mountain city of Saruun Khel. The hall is bisected by an underground river and protected by seven Minotaur statues -- "bronze warders" capable of being animated by the Mages.



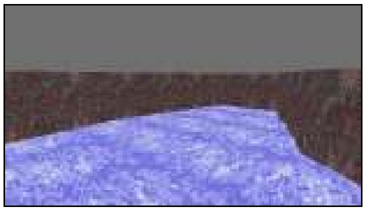
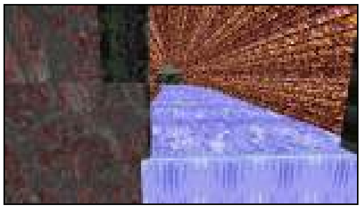
Chute in northern wall lowers water level, and the dark waters disappear from sight.

Two stone bridges broad enough to allow the passage of large carts.

Waterfall cascading from opening in southern rock wall allowing rain and glacial water to form a freshwater pool and river.

As Active Worlds is the oldest collaborative virtual world on the Internet, we'll look in a little more detail. This virtual world's colonized areas draw on the underground Planetary Veins for drinking water, water for crops, livestock and hydropower. Long ago, however, the veins were the Imperial Sewers. The veins move erratically due to the three moons and geothermal and volcanic activity.

As the veins open to a labyrinth of hospitable caves, at least two races are known to live below -- the Subminians and the Velosians. After finding the entrance, it's off to melancholy and strange country of fracture, and violence, and fire.

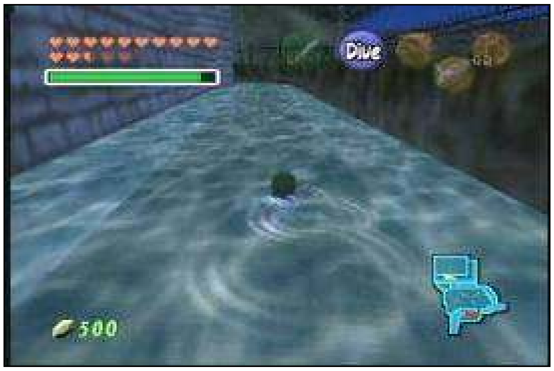
As there's no current going to Poison Lake, race the sub through the numerous splits, turns and double entrances. Because the River of Death is stagnant, one must pass through locks. Opening them quickly, however, may flood Poison Lake since it lies downhill from the volcano.

The River of Life has a current -- one can hear change in prop pitch and current against one's mini-submarine when going against the flow -- and surfaces occasionally in the Shadowed Jungle. Watch out for falling stalactites and a tidal whirlpool! Use navigation lights at intersections to see the underwater passages. When surfacing, take bearings with less than the top half of the sub exposed. A glass-shaft lock transitions the underground voyage from the subconscious to the super conscious.

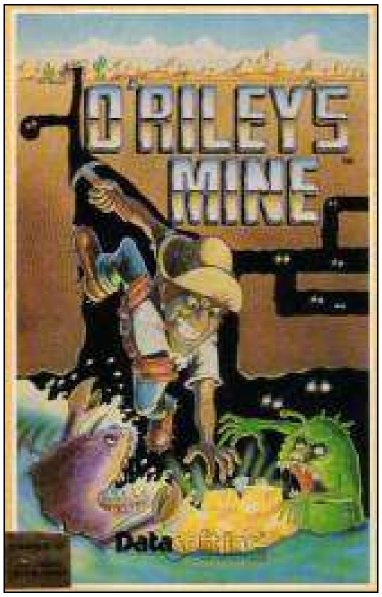
With less detail, below are screenshots from a variety of other games. We'll begin with a company that wasn't at all video-based in its founding.

Nintendo Corp. began in 1889 as a game card manufacturer.

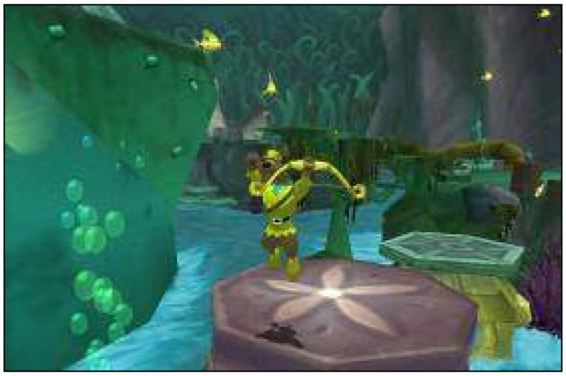
PLAYING CARDS
TRADE MARK
THE NINTENDO PLAYING CARD CO.
SHOMEN-DORI OHASHI,
KYOTO, JAPAN.



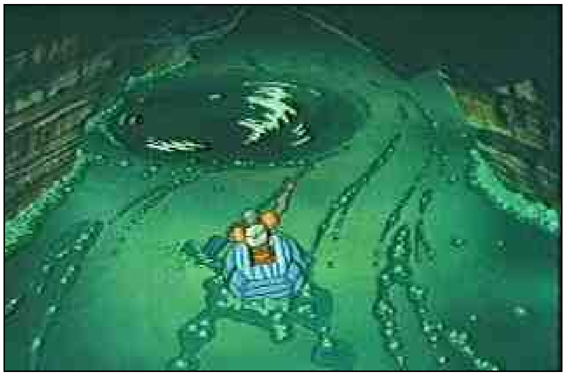
Fifty-seven million sales of The Legend of Zelda, however, helped make Nintendo the computer game giant we know today.


O'RILEY'S MINE
Data

In digging for coal, gold, diamonds, rubies and oil in O'Riley's Mine, avoid the creatures and rising underground river. The river is unstoppable, but the creatures can be blocked or killed with dynamite

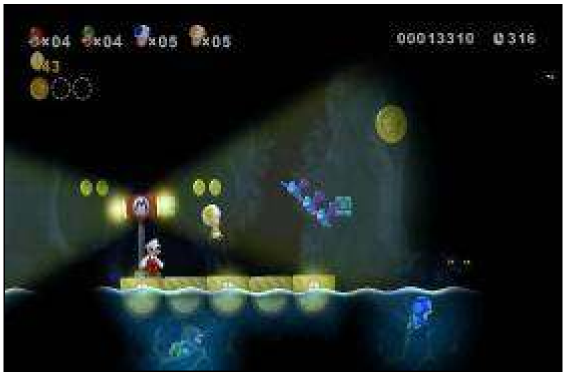


As we may need the audio cue when Scooby water-skis the underground river, Scooby-Doo! features a laugh track.

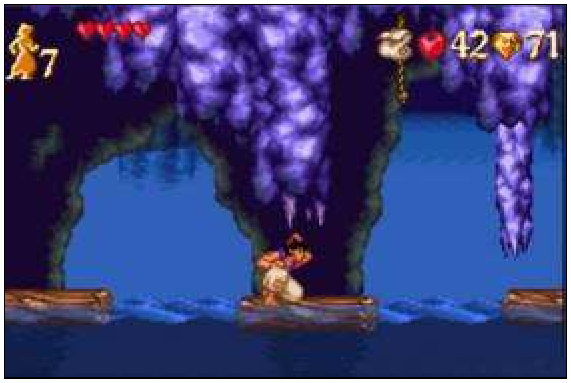


In Dragon's Lair, Dirk falls into a boat on a raging underground river. Move up each time it enters the calmer current. Avoid the whirlpools. When the boat hits the wall, grab the chain. The game's in its 60-th edition.

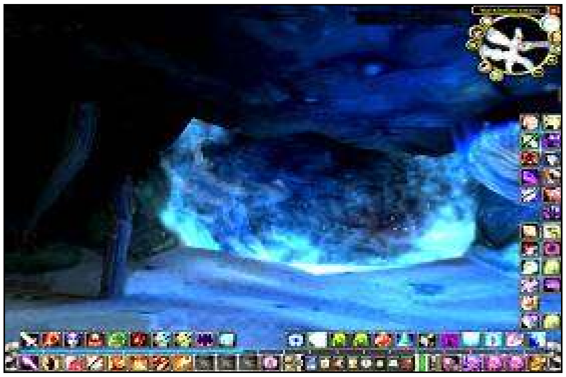
To get to the Water Stone, in Blue Dragon, sail south to the vast underground river "Hells Serpent."


×04 ×04 ×05 ×05
00013310 316
43

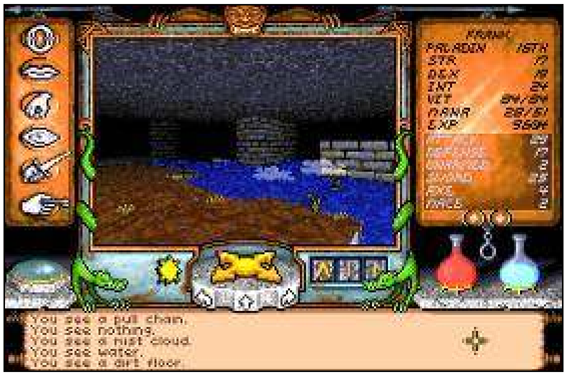
In the Super Mario Bros. "Misadventure of Mighty Plumber," Mario and Luigi are chased through an underground river in the Pipe Maze by Bowser and Mighty Plumber.



As Aladdin is a Disney offering, the underground river isn't that dangerous.

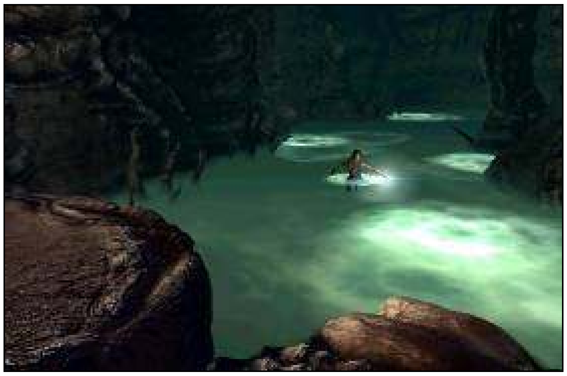


After reaching the first cavern of The Blackfathom Deeps, swim straight ahead to the above-water area.


FRANK
PALADIN 15TH
STR 17
DEX 19
INT 24
VIT 84/84
MANA 28/51
EXP 3564

You see a pull chain.
You see nothing.
You see a mist cloud.
You see water.
You see a dirt floor.

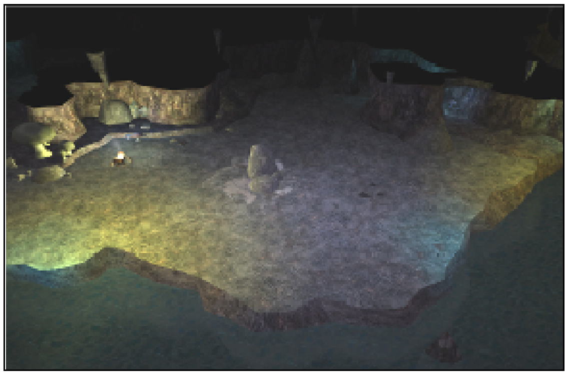
In Ultima Underworld, The Stygian Abyss, one must cross underground rivers, lava pools, slippery ice, sloped floors and doors that swing open and shut.



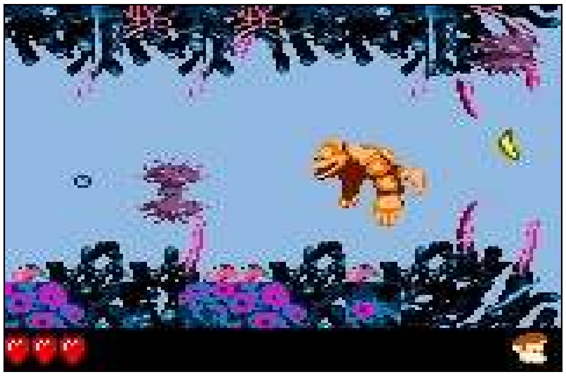
The ripples in Alone in the Dark follow Aline through the water. A zigzag pattern can help avoid an initial attack.

From the description of A Dance with Rogues

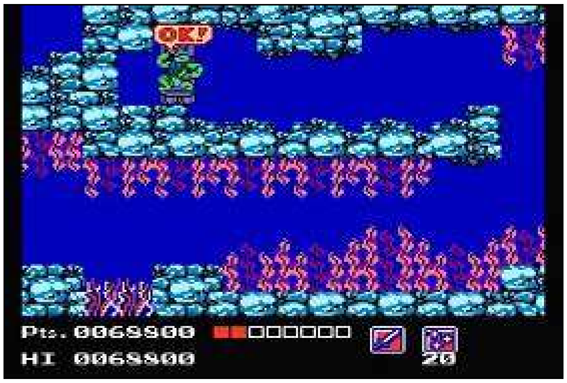
> *After going over the waterfall in the Abandoned Mine, you'll find yourself in the Underground River and a few party members short. Remaining party members will need healing and Anden will need to be resurrected. If Pia, Bran, or Gemli are in your party, they'll be missing.*



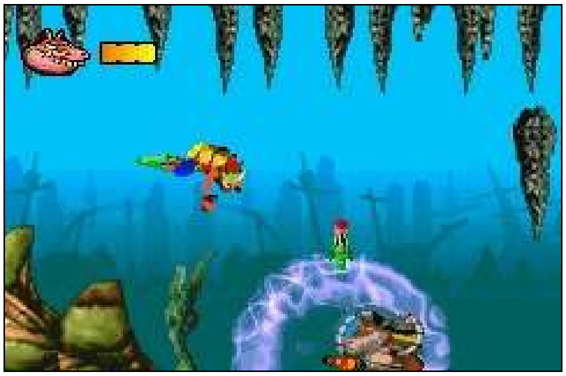
And then there the underground waters that must be swum.



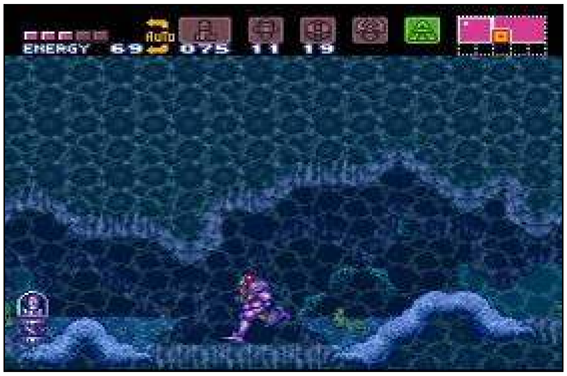
Donkey Kong. Barbos blocks Kiddy's path.



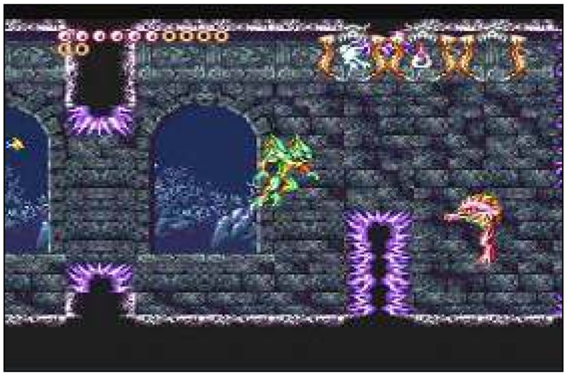
Teenage Mutant Ninja Turtles. Watch out for the seaweed.



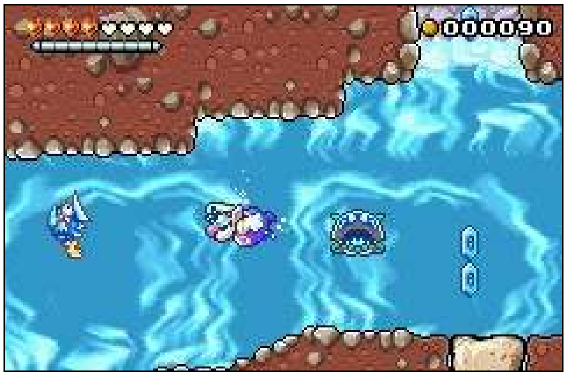
Crash Bandicoot. The boss makes the rocks fall down by shooting them.



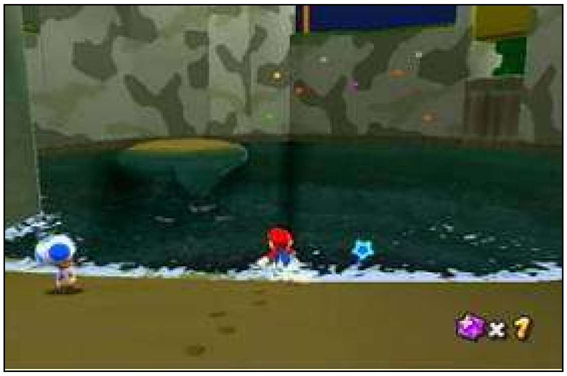
With a Metroid gravity suit, one can move freely underwater.

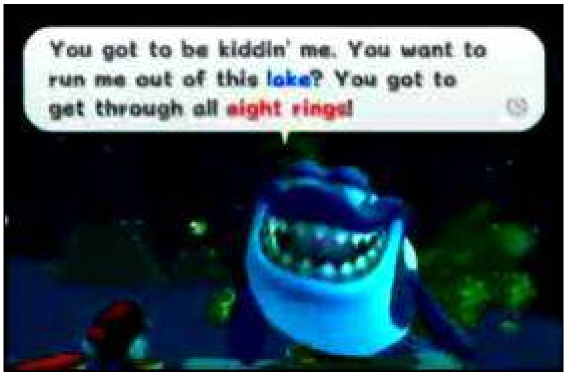


Underwater, the Demon's Crest controls are completely different. Don't swim into the spikes.



Wario swims the underground river of Wario Land.

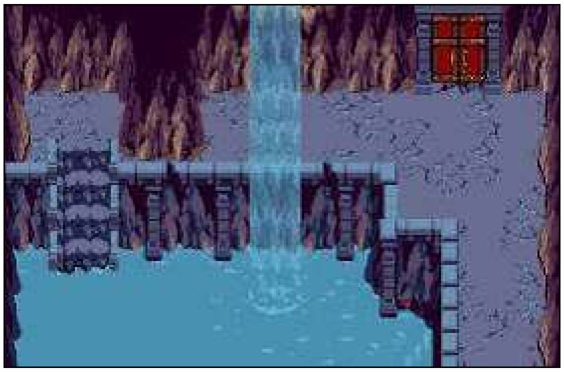




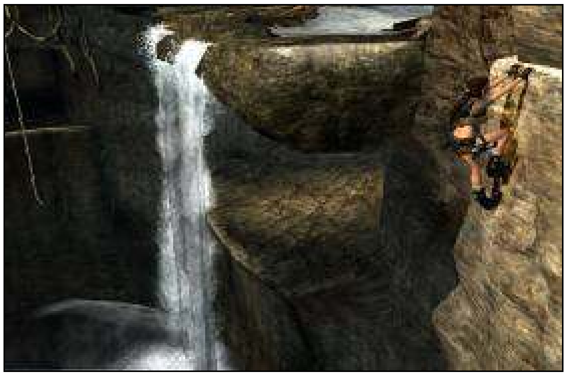
You got to be kiddin' me. You want to run me out of this lake? You got to get through all eight rings!

Super Mario, Guppy and the Underground Lake

Video games contain lots of waterfalls.

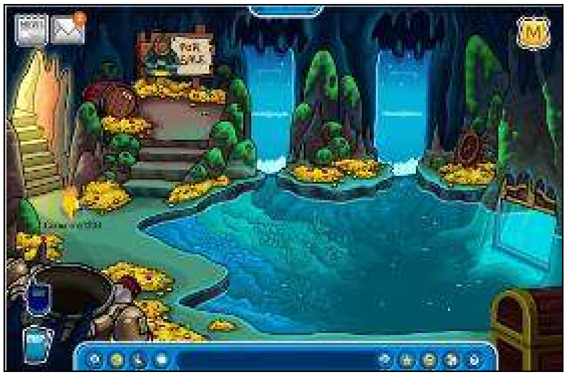


In Beyond Oasis, each waterfall leads to a lower underground river, but some lead to prizes such as the Infinite Metal Bow. Once at the bottom, take the stairs on the right to reach the top and try again



Tomb Raider features lovely, intelligent, athletic and reckless archaeologist Lara Croft who ventures into ancient and hazardous ruins. As Lara's been in a myriad of games, movies, animated series, comics and even theme-park rides, she's expert in subterranean waters.

Club Penguin is a massively multiplayer online role-playing game involving a virtual world containing a range of activities. The success of Club Penguin led to its purchase by Disney for $350 million, with a like amount to be paid in bonuses should specific targets be met.

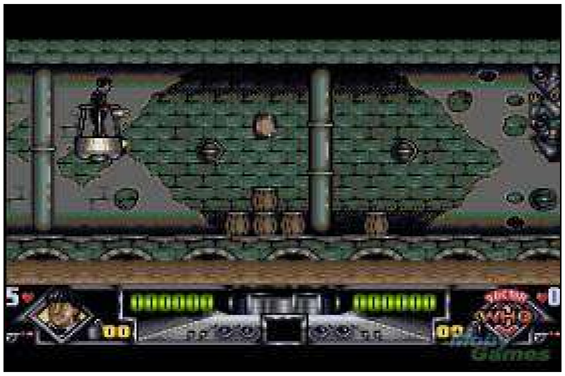


Club Penguin's New Mine Cave Room ...

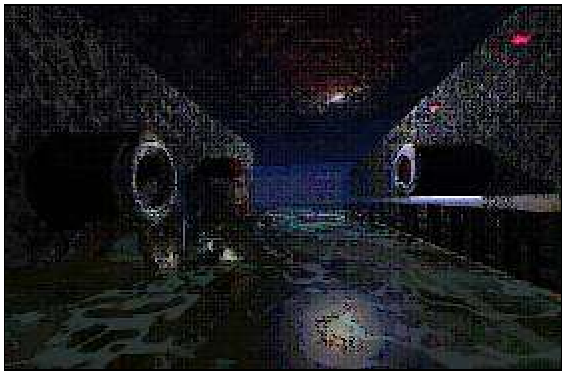
Deep Sea Diving Suit
50
BUY

... for which a diving suit is required.

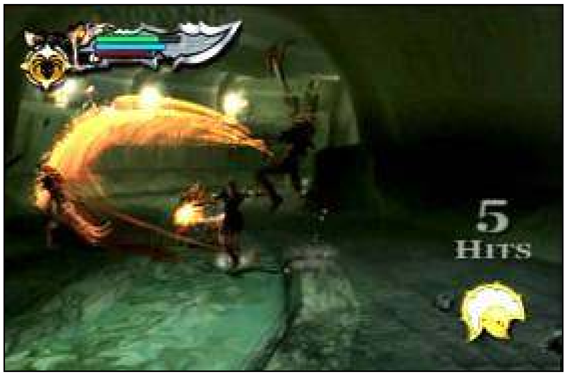
And less pleasantly, there are the sewers that must be traveled.



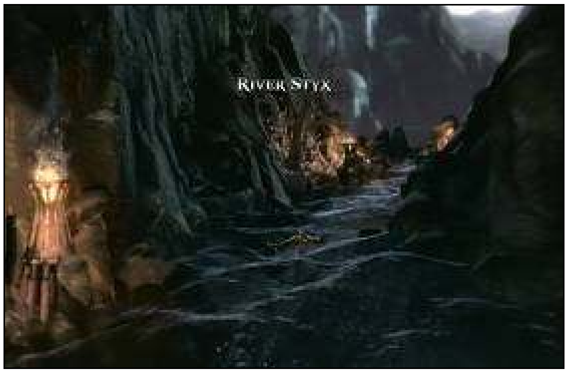
A sewer scene from Dalek Attack, based on the Dr. Who BBC series.



In Faction Earth, the limestone beneath Florida has faulted and most of the Gator State has sunk into the underground waters. And then there are the underground rivers of sewage.



The sewers of Athens in God of War.



Another setting within the same game

The Underground River in A Dance with Rogues' Sewers of Betancuria is infested with sword spiders and rats.

We'll have more to say about sewers -- and not the virtual variety -- in Chapter 58, The Grand Tour, European Sewers of Distinction.

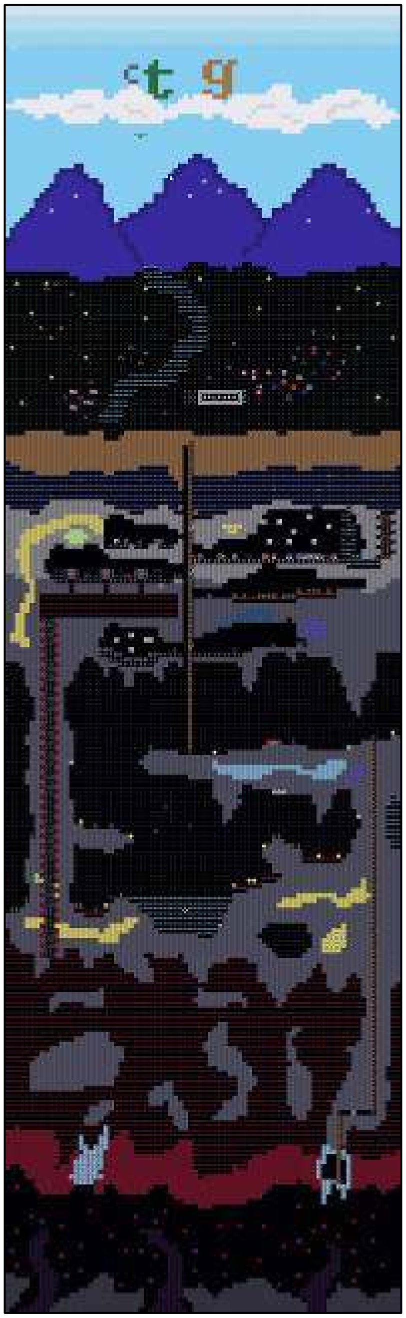
Most virtual-world gamecraft portrays underground rivers as static features to be negotiated, much the same as magic mountains or pits to doom. But now and then we encounter a subterranean stream that works as a subterranean stream should.

From the on-line discussion regarding Slaves to Armok: God of Blood,

> *What causes an underground river to flood/back up?*

This underground river is a feature of a fantasy world in which the laws of physics need not apply, but by the gamers' responses, we're impressed by the correspondence to reality.

> *A couple of years after carving fortifications in the "dry" part of one stretch of river so I could shoot the beasties within, the river suddenly overflowed and flooded every mining shaft I had below the highest level of river. The fortress itself, thankfully, remains untouched. I'm currently trying to find ways to drain the river of its excess so that I can reclaim the silver I dug out.*
>
> *The only time I have had an underground river "flood" is when I dammed the outflow and the source was higher than the dam.*
>
> *You probably made the fortification on the same level the water is on, thus letting it flow in; as of right now, cave rivers never flood on their own. The only case I've had where a cave river "flooded" is when an aquifer was pumping in more water then what could drain off, or the lower portion was sealed partially or totally in some way.*
>
> *I dug my fortress near, above and around an underground river. Eventually I dug extension tunnels across the river and down to access it its lower parts, trying to make an underground cave fishing pond. The river eventually rose and flooded up into my extension tunnels. I realized it was because the river was filling to the z-level of the highest river point. Later I used the flood waters to irrigate another chunk of underground forest.*
>
> *The "waterfall from nowhere" tiles which source underground rivers produce water far more quickly than it can drain off the edge of a map -- if your embark region contains the underground river source but does not contain the ending chasm, it is guaranteed to flood up to the source's level.*



Games need not be just for those who follow the rules. Splloder is a web platform for those who invent their own. From the website,

> *Choose one of the free Flash game creators from the list at top to create and edit your games. With Sploder you can create free platformer flash games, 3d space adventure games, and our class shooter games.*
>
> Save the Underground River is such a game.

YOU ARE PLAYING:
Save the Underground River
DIFFICULTY
3
MISSION:
DESTROY ALL ENEMIES
CLICK TO PLAY!

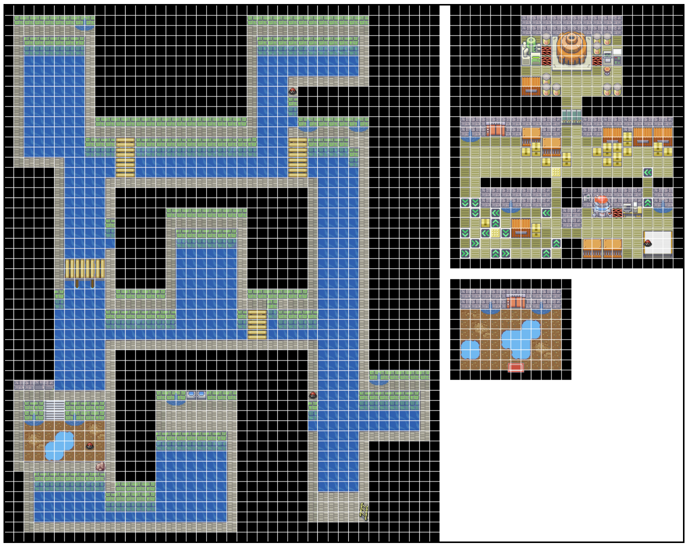
And let us hasten to reinforce the educational side of things. Blending Instructional Design Principles with Computer Game Design, The Development of Descartes' Cove, Educational Multimedia and Hypermedia, 2005, Montreal, by Patricia Wallace, describes computer-based role-playing to create mathematics adventures for middle school and early high school students.

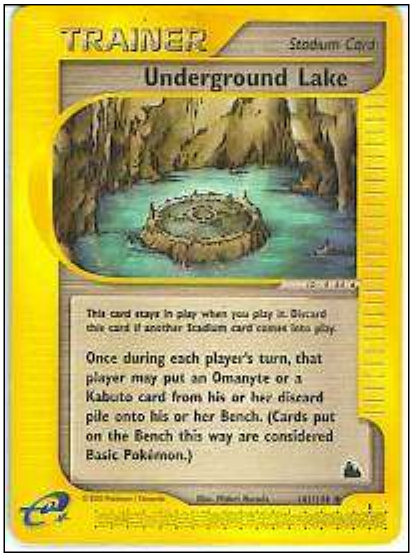
According to the author, whom we're told has a PhD,

> *In a leaky lifeboat, students survive an ocean storm and become marooned on the Cove's beach. Once they gather their gear, they can begin one of the adventures through the island's underground rivers, castle, jungle, mining caves, and volcano paths. They collect coins and inventory items as they solve math problems, explore new areas, and eventually reach Hypatia's Inlet where the problems are most difficult. Successful students can attempt the Final Quest (final exam), and enjoy a breathtaking escape.*

We're in favor of mathematical education, of course, but we suspect the kids already know from their own computer games how to escape via an underground river.

Pokemon can be played both on the game board and on the screen. Shown below is the layout of the underground sewer and a game card.

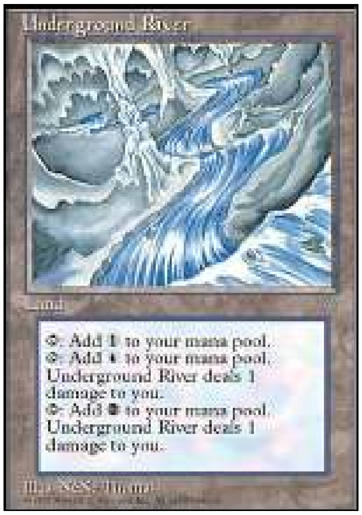


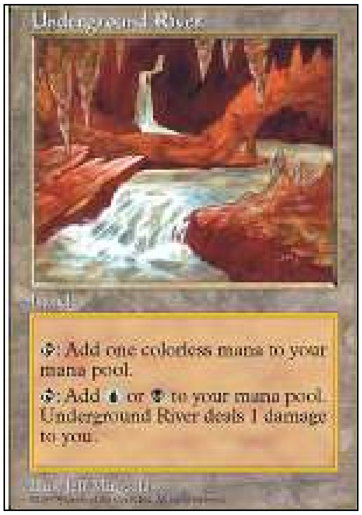


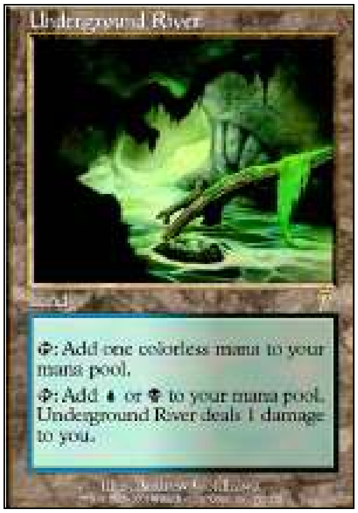
This card stays in play when you play it. Discard this card if another Stadium card comes into play.

Once during each player's turn, that player may put an Omanyte or a Kabuto card from his or her discard pile onto his or her Bench. (Cards put on the Bench this way are considered Basic Pokémon.)

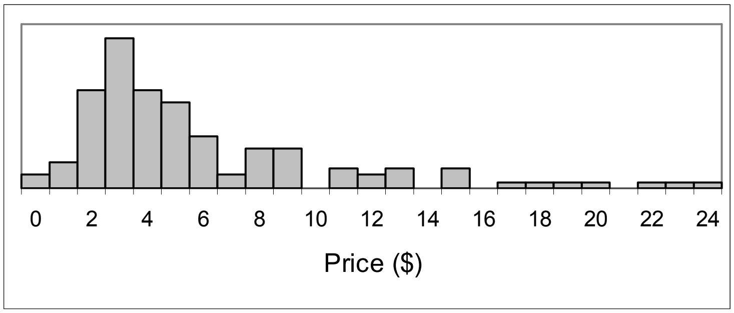
Although Magic can be played electronically, aficionados tend to prefer the playing-card version where players duel by casting spell cards which can have a single, one-time effect, set up a lasting magical enchantment or summon a creature for assistance. Over 8000 unique cards have been produced.


Underground River
Land
: Add 1 to your mana pool.
: Add to your mana pool. Underground River deals 1 damage to you.
: Add to your mana pool. Underground River deals 1 damage to you.

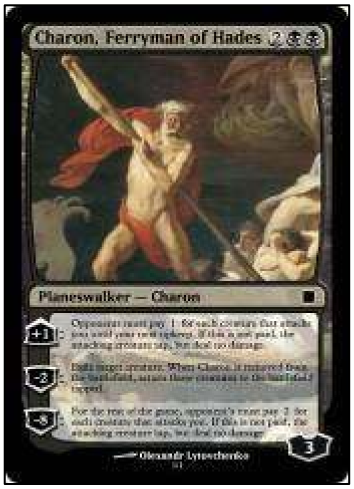

Underground River
Land
: Add one colorless mana to your mana pool.
: Add or to your mana pool. Underground River deals 1 damage to you.


Underground River
Land
: Add one colorless mana to your mana pool.
: Add or to your mana pool. Underground River deals 1 damage to you.

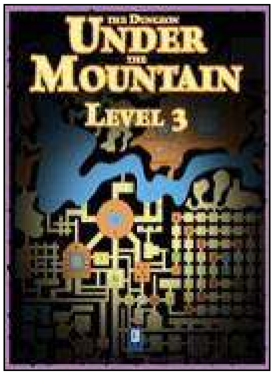
Prices to the right are for Underwater River cards advertized on e-Bay. As value depends upon the edition, Charon's two-obol fare has inflated to as much as $25.



We add another Magic card to our collection, Charon, Ferryman of Hades, though this one's unofficial. Players can create their own. In Chapter 33, Twenty-Five Centuries of Subterranean Portraits, we'll note the 1861 source of the image, but more to the point of this chapter, see the trading-card format in graphic art of 250 years yet earlier.


Charon, Ferryman of Hades
Planeswalker — Charon
+1
-2
3
Oleksandr Lytvynchenko

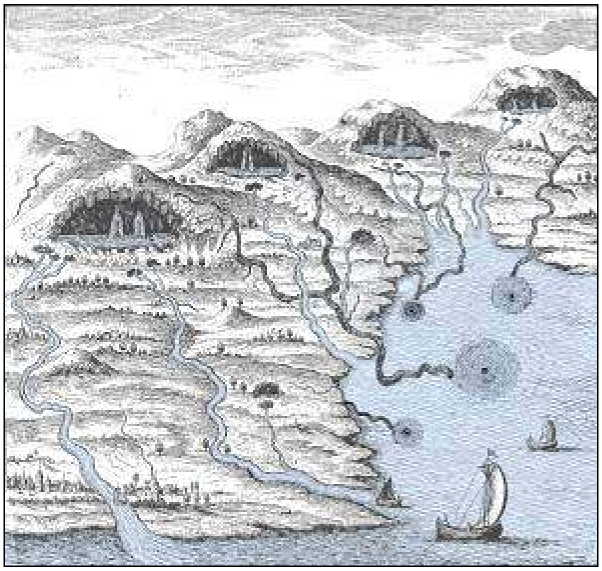
Dungeons and Dragons is likewise primarily a board game.

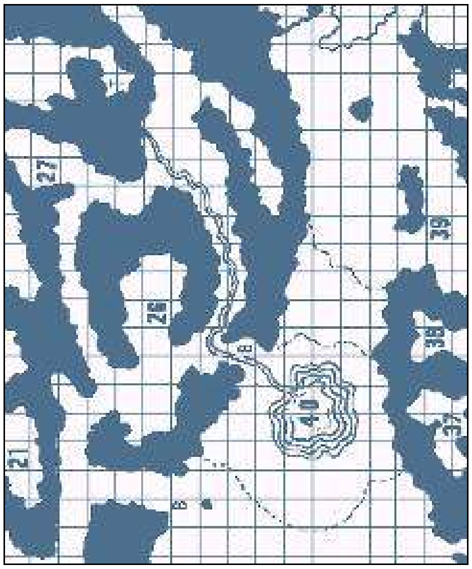

THE DUNGEON
UNDER
THE
MOUNTAIN
LEVEL 3

In Dungeon Under the Mountain, the underground river seems ancient. The remains of a lost city lie scattered; forgotten temples and pyramids tower in the darkness. But what inhabits the great underground river?

The Cavern Layout Kit includes effects for an underground river and lake. The floor tiles are based on 1-inch squares for Dungeons and Dragons. At $139.00, it's pricy, but not for the serious gamers.

Compare Kircher's mapping of subterranean flow to the Dungeons & Dragons board Descent into the Depths of the Earth.



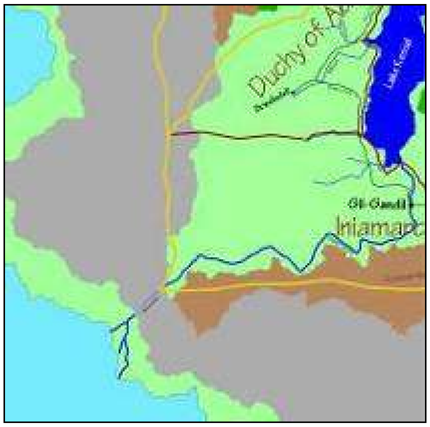


Who but Kircher would have foreseen the future with such precision?

In The Adventurers, Temple of Chac, there's a lava room to cross on tiles, some booby-trapped. There's an underground river to escape from the temple, or to quick demise over a treacherous waterfall.

Not all fantasy games are sedentary. NERO is a live action role-playing event set the medieval fantasy world of Tyrra in which heroes and heroines battle necromancers, goblins, zombies and other unsavories.

A singe event can take a three-day weekend.



In the portion of the game-field above, note the underground river leading to the sea.

And not all fantasy games need even be games; they can be pewter miniatures.

Why Do Such Games So Often Involve Underground Rivers

Underground rivers engage our senses.

1. Underground rivers are visual.

Given the dollars spent on virtual realities, the academics have followed the scent. "The Immersant Experience of Osmose and Ephémère," 15th International Conference on Artificial Reality and Telexistence (2005) by Harold Thwaites ranks virtual locational aspects by evoked emotion or physical sensation.

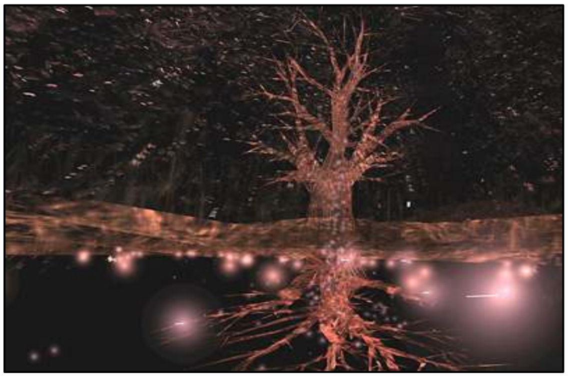
39%	Lights, Fireflies/Wonderment, Peace, Joy, Delight
32%	Underground/Scary, Unfamiliar, Spooky, Off Balance
20%	Tree, Forest, Pond/Awe, Curiosity, Exhilaration, Floating, Fantasy

Which is to say that it works well to combine a subterranean location with moving water.

Game designers could replace underground rivers with, say, pneumatic tubes or mini subways, but then we'd not have the virtual rafts and canoes. As we will note another subway connection in Chapter 81, East Side, West Side, All Around the Town, it's easier to believe in imaginary worlds having to real-world experiences.

We turn to an example -- Osmose's three-dimensional Cartesian grid in which the immersant emerges in a clearing where there's a pond into which one can descend into an oceanic abyss.

This isn't Mario hopping down a shaft between Lego-like rectangles. Like Alice in Wonderland (Chapter 16, Underground Rivers in English Fiction), we are the ones descending..



2. Underground rivers are audible -- or more truthfully worded, we imagine them to so be

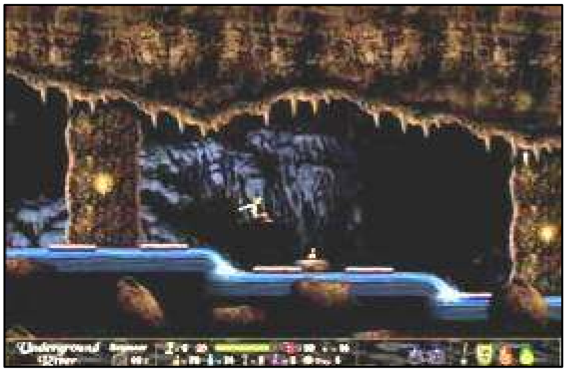
Portrayed sounds draw the reader into the experience. It is no surprise that in the popular ranking of video games, the audio track is almost as important as are the visual effects.

It is Dark Castle's multimedia effects -- rudimentary by today's technology -- that evoked this reflection in the Georgia Tech Game Morphology Project.

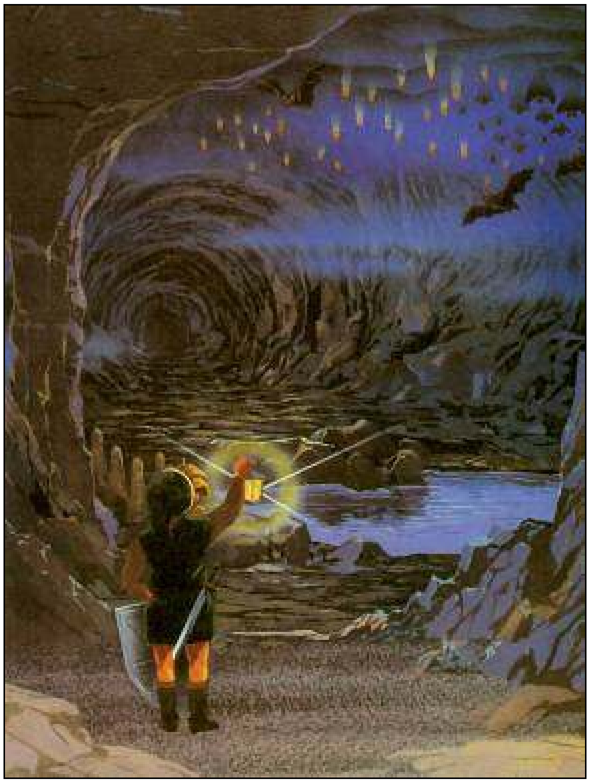
> *Amazing graphics and sound. This game was completely addictive and, for its time, totally immersive. The first time I saw it I couldn't believe the imagery -- like interacting with the images in book of fairytales or a theme park ride. I still remember the sound of the rushing underground river.*

From Wikia Gaming Spoilers and Hints,

> *On the far right edge of the screen in Castle Grounds, there's an invisible switch. Use it to make a rope go down the well. Climb down to the Underground River.*
>
> *If you ride at the very front of a log, then when it goes down a short waterfall, you'll go "Woah!" then fall onto the back of the log. This does not work on long waterfalls.*
>
> *There are a limited number of logs, so when you have to climb ropes and platforms, go quickly.*



We'll end our journey along virtual underground rivers with a look into the Melora Cave of Zelda.



For millennia we've fantasized visions of underground rivers and now we can enter them in multimedia from the comfort of our chairs.

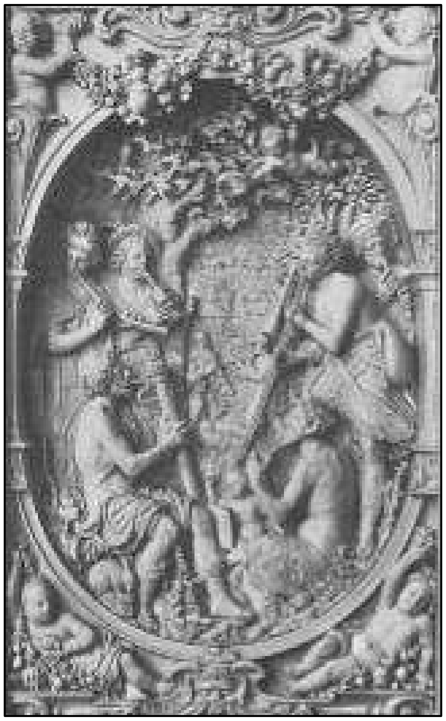
CHAPTER 28

ET IN ARCADIA EGO

The Greek portion of our journey has to this point largely been one of chronicling the entrenchment of Homer's underground rivers of the afterlife -- the Cocytus, Lethe, Acheron, Styx and Pyriphlegethon -- into modern thought. We'll see more of the subject in chapters to come.

But Caron's waters are not the only subterranean Greek streams formative to Western culture.

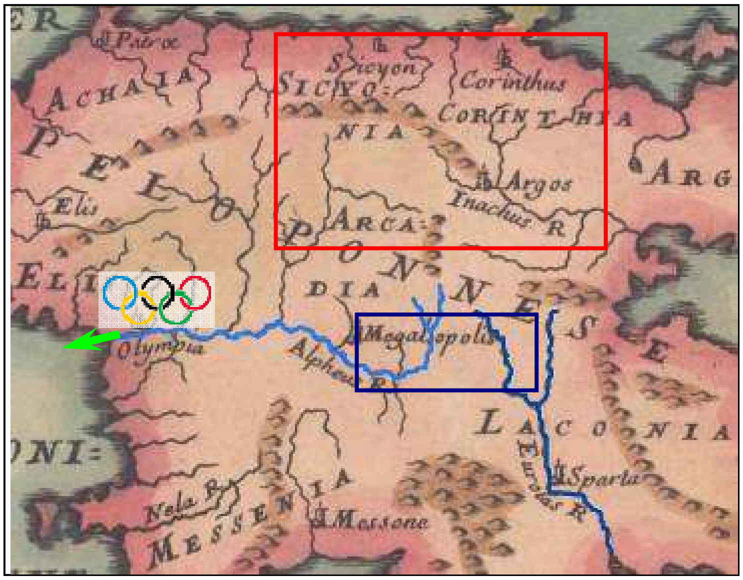
In chapters ahead we shall explore the themes of underground rivers in metaphor, poetry and art, but let us first visit the Arcadian River Alpheus on the rugged Peloponnese Peninsula, home to Pan, god of nature and patron of shepherds.



Aristotle's Meteorologica considered the subject, but true to the author's bent for logic over lore, in a more mechanical sense.

> *In many places: in the Peloponnese, for example, one finds it* [i.e. underground rivers] *most often in Arcadia.*
>
> *The rivers that are swallowed up by the earth prove that there are chasms and cavities in the earth ... in the Peloponnese, for example ... The reason is that because the country is mountainous there are no outlets from the valleys to the sea; so when these valleys get filled with water and there is no outlet, the water flowing in from above forces its way out and finds a way through into the depths of the earth.*

The Alpheus, the peninsula's longest waterway, is mapped below in light blue; the southerly River Eurotas is in darker blue.

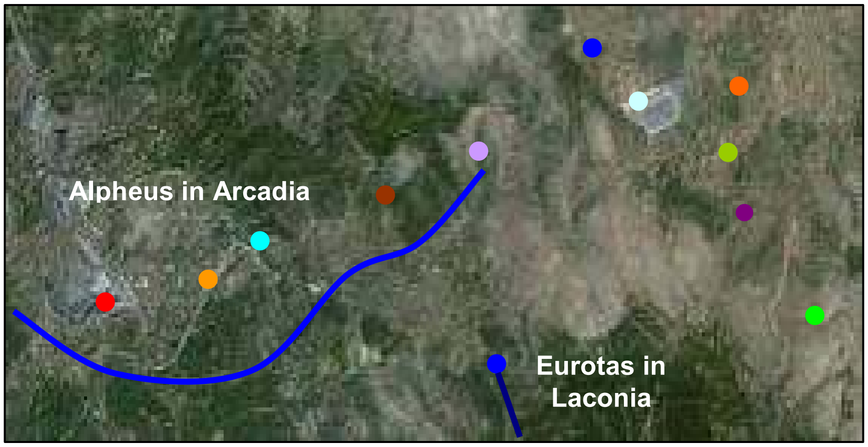

Patræ
ACHAIA
PELOPONNESUS
Elis
ELIS
Olympia
Sicyon
SICYONIA
Corinthus
CORINTHIA
Argos
Inachus R
ARG
ARCADIA
Megalopolis
Alpheus R
LACONIA
Eurotas R
Sparta
Nela R
MESSENIA
Messene
IONI

River Alpheus

The red rectangle corresponds to Chapter 3's topographic map of modern rivers associated in name with those of the classical underground. The blue rectangle shows the headwater proximity of the Alpheus and Eurotas. The Olympic symbol marks the town by that name and the green arrow, the Alpheus outflow.

Headwaters

The aerial photo below corresponds to the blue rectangle above and shows approximate locations cited in four writings describing the Alpheus headwaters. We must be cautious, however, in connecting the dots, as geographic names have migrated over the centuries. We're more interested in cultural perceptions than actual plumbing.


Alpheus in Arcadia
Eurotas in Laconia

- ● Megalopoli
- ● Mt. Tzimbaru
- ● Rhapsonati
- ● Asea
- ● Pegse
- ● Bleminatis
- ● Lake Taki
- ● Tegea
- ● Symbola
- ● Sarandapotamo
- ● Phylace

For the source material in this chapter, we'll draw from several of the Roman Encyclopedists of Chapter 3.

In Geogrpahia, Strabo (63 BC-24 AD) stated that the Alpheus and Eurotas rise from two fountains near Asea, and that, after flowing underground for several stadia [one stadia equals 150-200 meters], the Eurotas reappears at Bleminatis in Laconia, and the Alpheus in Arcadia.

Strabo's Geographia noted the popular belief that if two garlands dedicated to the Alpheus and the Eurotas were thrown into the stream before in plunged underground near Asea, each would reappear in its appropriate river, but Strabo, himself, disagreed for several reasons.

> *They say that it is the river Alpheus which rises in the Peloponnesus, and that it flows through the land beneath the sea to the place where the Arethusa rises and flows into the sea. Some such proofs as these are given in support of the fact.*

1. The cast up chalice

> *A certain chalice having fallen into the river at Olympia was cast up by the springs of Arethusa; the fountain too is troubled by the sacrifices of oxen at Olympia. And Pindar, following such reports, thus sings,*
>
> > *"Ortygia, revered place of reappearing of the Alpheus,*
> > *The offset of renowned Syracuse."*
>
> *The fable of the chalice being carried over is likewise a mere fabrication, for it is not calculated for transfer, nor is it by any means probable it should be washed away so far, nor yet by such difficult passages. Many rivers, however, and in many parts of the world, flow beneath the earth, but none for so great a distance.*

As this chalice would prove to be long cited, we'll give it more attention a bit later in this chapter.

2. The lack of a chasm

> *Undoubtedly if before reaching the sea the Alpheus were to fall into some chasm, there would be a probability that it continued its course from thence to Sicily,.. but since the mouth of the river manifestly falls into the sea, and there does not appear any opening in the bed of the sea there, which would be capable of imbibing the waters of the river.*

Were the Alpheus to empty into a visible chasm, however, Strabo implies that it would be plausible for the flow to continue a submarine course as far as Sicily.

3. The Arethusan spring's fresh water

> *It might be possible to retain much of the character of fresh water, if they were presently to be swallowed down into a passage running below the earth which forms the bed of the sea. It is altogether impossible; and this the water of Arethusa clearly proves, being perfectly fit for beverage; but that the flow of the river should remain compact through so long a course, not mixing with the sea until it should fall into the fancied channel, is entirely visionary.*

Strabo finds the Alpheus to be entirely unlike the Rhone, which he indeed believed to flow underground.

> *For we can scarcely credit it of the Rhone, the body of the waters of which remains compact during its passage through the lake, and preserves a visible course, but in that instance both the distance is short and the lake is not agitated by waves like the sea, but in this case of the Alpheus, where there are great storms and the waters are tossed with violence, the supposition is by no means worthy of attention.*

Strabo offers another possible source of the Alpheus, but as a citation not to be believed.

> *Zoilus the rhetorician, in his Eulogium of the people of Tenedos* [an Aegean island off modern Turkey] *says that the river Alpheus flows from Tenedos*

Pausanias (Chapter 3) leaves unclear what's personal observation and what's not, his Description of Greece is the best surviving geography of Greece in Roman times.

> *It is known that the Alpheus differs from other rivers in exhibiting this natural peculiarity; it often disappears beneath the earth to reappear again. So flowing on from Phylace and the place called Symbola it sinks into the Tegean plain; rising at Asea, and mingling its stream with the Eurotas, it sinks again into the earth.*

The Dictionary of Greek and Roman Geography (1854) by Sir William Smith had this to say,

> *The two reputed sources of the Alpheus and Eurotas are found near the remains of Asea, at the copious source of water called Frangovrysi; but whether the source of the Alpheus be really the vent of the lake of Taki, cannot be decided with certainty.*

DESCRITTIONE
DELLA
GRECIA,
di Pausania.

NELLA QUALE SI CONTIENE

Tradotta dal Greco in volgare dal
S. Alfonso Bonacciuoli Gentilhuomo Ferrarese.

Al Ser.mo Sig. il S. Donno Alfonso
d'Este Duca di Ferrara, &c.

IN MANTOVA,
Per Francesco Osanna Stampator Ducale,
M D XCIII.

According to the Cyclopaedia of the Society for the Diffusion of Useful Knowledge (1883),

> *Alpheus, one of the chief rivers of Peloponnesus. Its rise and early course are marked by some singular circumstances.*
>
> *According to Pausanias, the fountain is at Phylace, near the foot of Mount Parthenius, at the southeast corner of Arcadia, where the boundaries of Arcadia, Argolis, and Laconia meet.*
>
> *Near a place called Symbola, (the "meeting of the water") it is joined by a considerable stream, and sinks underground; it rises again five stadia from Asea, close to the fountain of the Eurotas. The two rivers then mix their waters, and after flowing twenty stadia, are again swallowed up, and re-appear -- the Eurotas in Laconia, the Alpheus at Pegse (the Springs), in the Megalopolitan territory, and in Arcadia.*
>
> *The statement of Pausanias is confirmed, and the course of the upper stream (now the Sarandapotamo) traced by Colonel Leake to the spot where it enters the earth below Phylace. He confirms the statement of its rise (or at least the rise of some subterranean stream) at Francovrysi, near Asea. Here there are two sources or emissaries, one of which he supposes to be the vent of the lake or marsh called Taki, not far from Tegea, north-east of Francovrysi; the other that of the Sarandapotamo. One of these probably is the supposed source of the Eurotas, mentioned by Pausanias. These streams, after joining, enter a lake, and again sink into the earth. Passing under a mountain called Tzimbaru, the Alpheus reappears at Marmora, near Rhapsonati.*
>
> *These subterranean descents are not uncommon in the Arcadian rivers, and are called by the modem Greeks, Katavothra: similar instances are collected in the Encyclopedie Methodique; Geog. Physique.*

Where the headwaters sink and where they then rise has been of geographic interest for millennia.

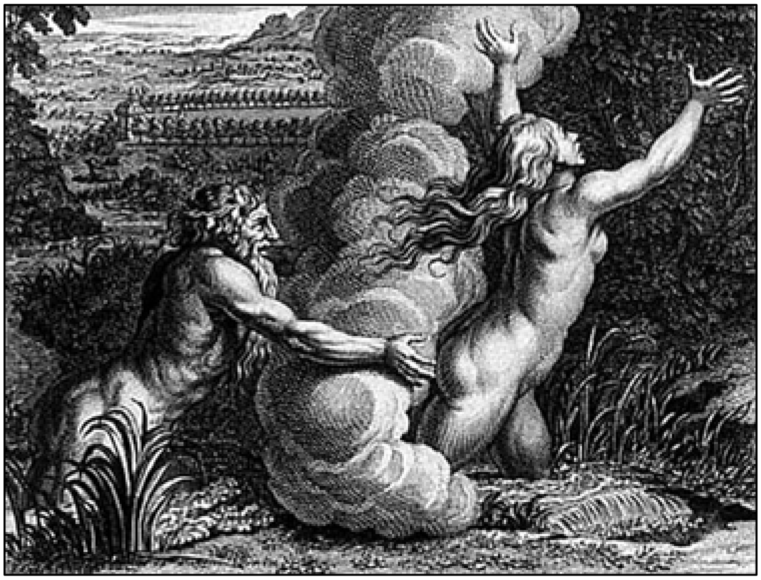
"But Some Waters So Hate the Sea"

According to the Aeneid of Virgil (70-19 BC),

> *The story goes that Alpheus, a river of Elis, forced a hidden path here under the sea, and merges with the Sicilian waters of your fountain Arethusa.*

Ovid's Metamorphoses by Ovid's relates how the river god Alpheus pursued the beautiful nymph Arethusa who bathed in his waters. Appealing to her patron Diana, goddess of nature, to escape, Arethusa was transformed into water.

> *I cried out "Help me. I will be taken. Diana, help the one who bore your weapons for you, whom you often gave your bow to carry, and your quiver with all its arrows!" The goddess was moved, and raising an impenetrable cloud, threw it over me.*
>
> *The river-god circled the concealing fog, and in ignorance searched about the hollow mist. Twice, without understanding, he rounded the place, where the goddess had concealed me, and twice called out 'Arethusa, O Arethusa!'*
>
> *Cold sweat poured down my imprisoned limbs, and dark drops trickled from my whole body. Wherever I moved my foot, a pool gathered, and moisture dripped from my hair, and faster than I can now tell the tale I turned to liquid. And indeed the river-god saw his love in the water, and putting off the shape of a man he had assumed, he changed back to his own watery form, and mingled with mine.*



To the right, "Arethusa Pursued by Alpheus and Turned into a Fountain," 1731 by Bernard Picart.

To assist Arethusa's escape, the goddess split the earth between Greece and Sicily, providing a subterranean path to re-emerge as the Arethusa Fountain.

> *The Delian goddess split the earth, and plunging down into secret caverns, I was brought here to Ortygia, dear to me, because it has the same name as my goddess, the ancient name, for Delos, where she was born, and this was the first place to receive me, into the clear air.'*

But Alpheus pursued her under the sea, intermingling his waters with hers, but not the ocean.

Unlike many stories clearly passed from Greek tradition, Ovid's sources for the tale are uncertain, but the story is one that well illustrates the Roman claim to the deep and powerful purity of the Greek cultural connection.

In another version, Arethusa was always located in Syracuse and it was the River Alpheus who made his underground way to Syracuse to be united with her.

According Pliny's Natural History,

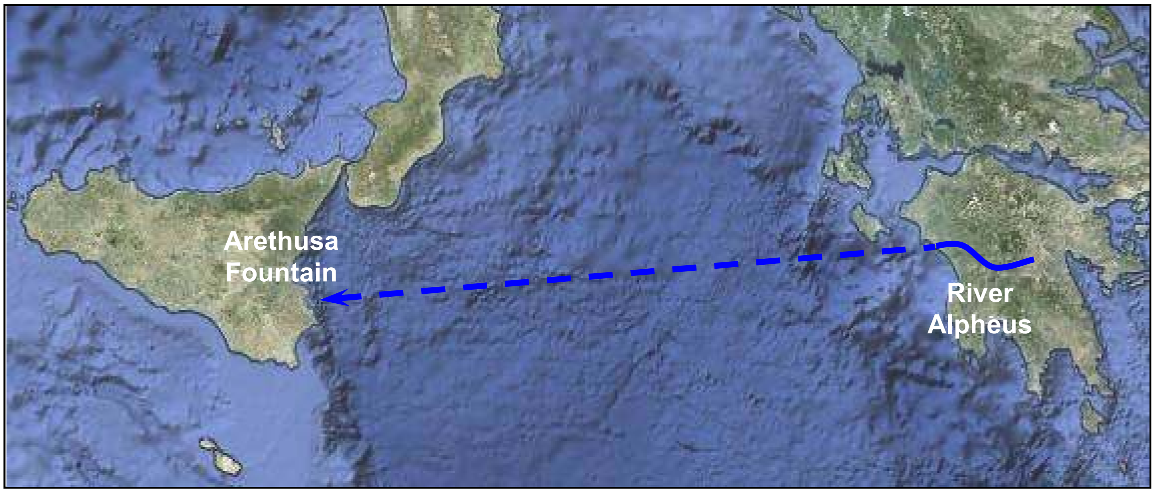
> *But some rivers so hate the sea, that they actually flow underneath the bottom of it, for instance the spring Arethusa at Syracuse, in which things emerge that have been thrown into the Alpheus which flows through Olympia and reaches the coast in the Peloponnese.*

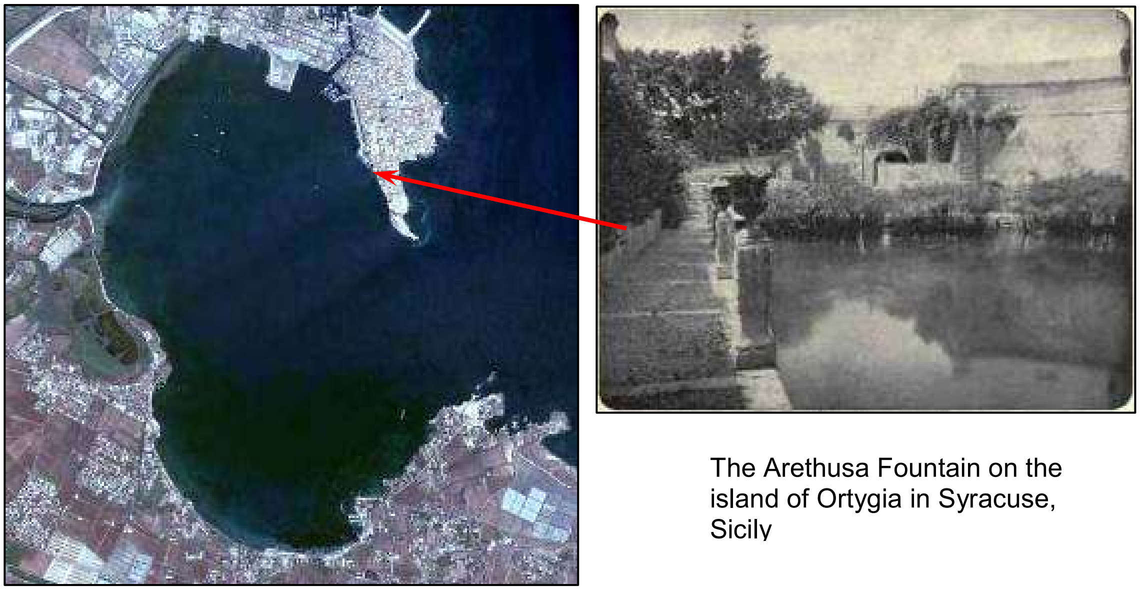
Pausanias included the following in his Description of Greece, clearly not first-hand knowledge.

> *Coming up at the place called by the Arcadians Pegse, and flowing past the land of Pisa and past Olympia, it falls into the sea above Cyllene, the port of Elis. Not even the Adriatic could check its flowing onwards, but passing through it, so large and stormy a sea, it shows in Ortygia, before Syracuse, that it is the Alpheus, and unites its water with Arethusa.*

The historian Timaios, on the other hand, professed to have personally verified that the fountain Arethusa was the reappeared Alpheus.

It was likewise said that the Fountain of Arethusa turned red after sacrifices at Olympia and that anything lost in the Alpheus eventually would be found in Syracuse.





The Arethusa Fountain on the island of Ortygia in Syracuse, Sicily

The Sicilian termination of the River Alpheus brings to mind da Vinci's speculation.

> *A spring may be seen to rise in Sicily which at certain times of the year throws out chestnut leaves in quantities; but in Sicily chestnuts do not grow, hence it is evident that that spring must issue from some abyss in Italy and then flow beneath the sea to break forth in Sicily.*

Da Vinci was mistaken regarding Sicilian trees, however. The chestnut is abundant from southern Europe to the Caucasus and occurs on many Mediterranean islands. Perhaps da Vinci (an innovative speller) meant Cilicia, the Mediterranean region south of the Taurus Mountains. Lost rivers of that region were indeed mentioned in works of which Leonardo would have been aware.

As a brief aside, we should note that subterranean-transported flora would long remain of interest. The Gallery of Nature (1882), Thomas Milner (Chapter 10) is precise on the matter.

> *At Tours, in 1830, a well was perforated quite through the chalk, when the water suddenly brought up from a depth of three hundred and sixty-four feet, a great quantity of fine sand, with*

> *much vegetable matter and shells. Branches of a thorn several inches long, much blackened by their stay in the water, were recognized, as also the stems of marsh plants, and some of their roots, which were still white, together with the seeds of the same in a state of preservation, which showed that they had not remained more than three or four months in the water. Among the seeds were those of the marsh plant galium uliginosum, and among the shells a fresh water species, (planorbis marginatus) and some land species, as helix rotundata and helix striata. M. Dujardin, who, with others, observed this phenomenon, supposes that the waters had flowed from some valleys of Auvergne or the Vivarais since the preceding autumn.*

Dominique Francois Jean Arago mentioned the same or similar event in Sur les Puits Fore (1834) in which the spring at a cathedral close to Tours increased by about a third, became turbid, and for several hours brought up with it pieces of wood and vegetation.

> *These facts prove without question that the underground water at Tours does not come (at least not entirely) from filtration through beds of sand. For it to be able to carry shells and pieces o/wood, it must have moved freely along proper channels.*

And we can yet add The Earth: A Descriptive History of the Phenomena of the Life of the Globe (1871) by Elisee Reclus.

> *In many places, especially at Tours, the artesian wells have ejected the remains of plants, branches, moss, snail shells, and other debris which the rains had probably carried away some weeks previously into the depths of the earth. At Elbceuf* [also in France] *the water of a well contained living eels.*

Da Vinci's submarine stream originates in Italy, not Arcadia, but given Leonardo's enthusiasm for ideas, it's not likely he researched his Latin sources.

The chalice tale is again and again cited by classical scholars, an example taken from A New Classical Dictionary of Greek and Roman Biography, Mythology, and Geography (1851) by Sir William Smith,

> *Hence it was said that a cup thrown into the Alpheus would appear again in the fountain of Arethusan Ortygia.*

"The Fountain of Arethusa," New York Times, July 7, 1901, remarks on the tourism aspect.

> *No object is more frequently mentioned in connection with Syracuse than Arethusa, the nymph changed into a fountain when pursued across the sea by the river Alpheus. The water of this fountain, much praised in antiquity, has in recent times become brackish by the letting in of salt water through earthquakes. But what it has lost in real excellence it has gained in stylish appearance. For the sake of its ancient renown washerwomen have recently been excluded from it, a fine wall put about it, and papyrus plants added to make it look picturesque.*

As the Alpheus below Olympia flows into the sea as a distinct channel at times of high discharge and as meandering threads in times of drought, the tale of the river god and the nymph seems to be rooted in river's more-perplexing headwaters. For direct delivery to Sicily, toss the cup in the river above Megalopoli, not at Olympia.

The Legacy

The mystery of the River Alpheus was an underpinning of Renaissance literary and art, but not simply as a river that stitched its way across Peloponnese. The deeper mystery was that of life's metaphorical destination.

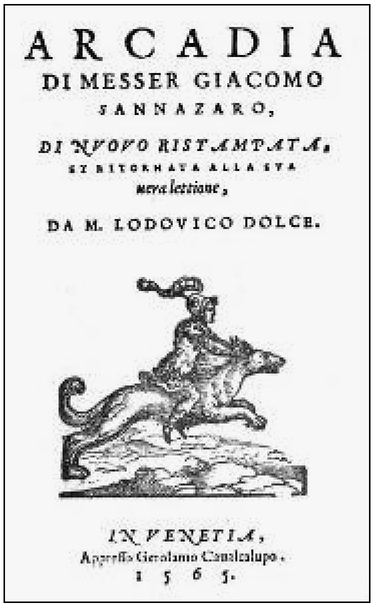
Cosimo de Medici (1389-1464), the first of the Florentine political dynasty, sent agents throughout Europe in search of ancient manuscripts and with these, founded the Academies to study Greek philosophy.

To writers and artists of the Renaissance having no knowledge of Arcadia's harsh topography, the land was a seen as a gentle, fertile, idealized landscape, a wishful vision of existence untouched by the conflicts of contemporary life. Unlike the word "utopia" -- named for Thomas

More's Utopia (1516), however -- "Arcadia" did not connote human progress, but rather the spontaneous result of life lived naturally.

The theme of Arcadia and its underground River Alpheus, in fact, became so prominent in Renaissance scholarship that the Academies were known as "Arcadians."

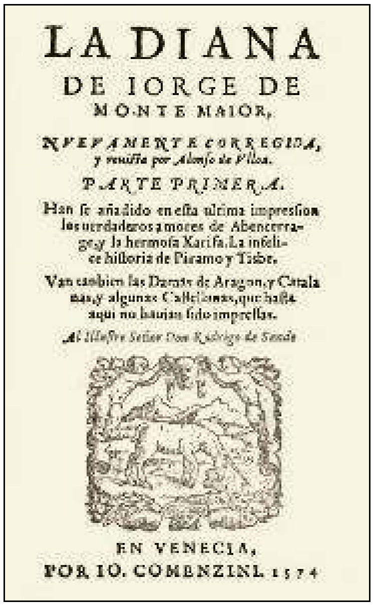
Following is an assortment of period literature set in -- and thus helping establish the idealized nature of -- Arcadia.



ARCADIA
DI MESSER GIACOMO
SANNAZARO,
DI NVOVO RISTAMPATA,
ET RITORNATA ALLA SVA
vera lettione,
DA M. LODOVICO DOLCE.

IN VENETIA,
Appreſſo Girolamo Cavalcalupo.
1565.

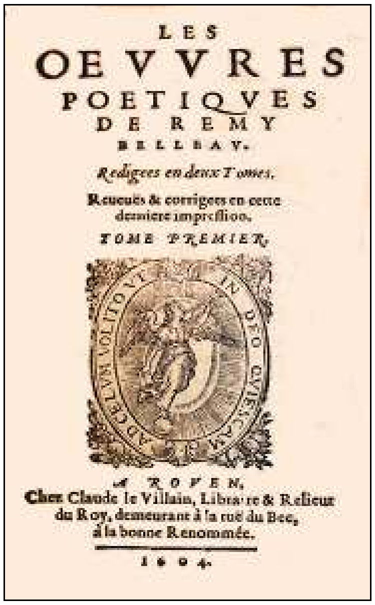
Jacopo Sannazaro
Arcadia (1502)



LA DIANA
DE IORGE DE
MONTE MAIOR,
NVEVAMENTE CORREGIDA,
y reuiſta por Alonſo de Vlloa.
PARTE PRIMERA.
Han ſe añadido en eſta ultima impreſſion
los uerdaderos amores de Abencerra-
ge, y la hermoſa Xarifa. La infeli-
ce hiſtoria de Piramo y Tisbe.
Van tambien las Damas de Aragon, y Catala
nas, y algunas Caſtellanas, que haſta
aqui no hauian ſido impreſſas.

EN VENECIA,
POR IO. COMENZINI. 1574

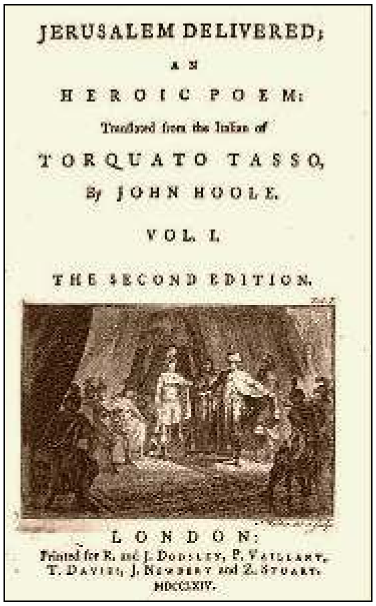
Jorge de Montemayor
Diana, (c. 1559)



LES
OEVVRES
POETIQVES
DE REMY
BELLEAV.
Rediges en deux Tomes.
Reueuës & corrigees en cette
derniere impreſſion.
TOME PREMIER.

A ROVEN,
Chez Claude le Villain, Libraire & Relieur
du Roy, demeurant à la ruë du Bec,
à la bonne Renommée.
1604.

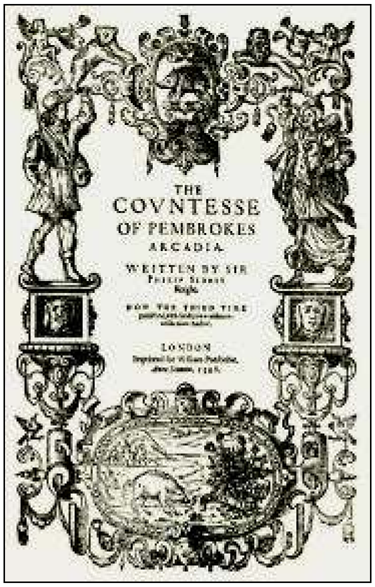
Remy Belleau
Bergerieby (1572)



JERUSALEM DELIVERED;
AN
HEROIC POEM:
Translated from the Italian of
TORQUATO TASSO,
By JOHN HOOLE.
VOL. I.
THE SECOND EDITION.

LONDON:
Printed for R. and J. Dodsley, P. Vaillant,
T. Davies, J. Newbery and Z. Stuart.
MDCCLXIV.

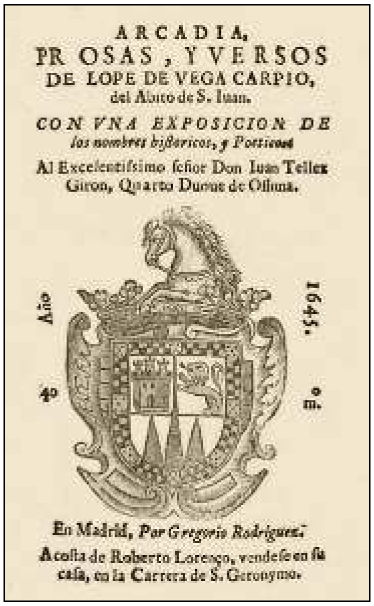
Torquato Tasso
Jerusalem Delivered (1581)



THE
COVNTESSE
OF PEMBROKES
ARCADIA.
WRITTEN BY SIR

LONDON

Philip Sidney
Countess of Pembroke's
Arcadia (1590)



ARCADIA,
PROSAS, Y VERSOS
DE LOPE DE VEGA CARPIO,
del Abito de S. Iuan.
CON VNA EXPOSICION DE
los nombres hiſtoricos, y Poeticos
Al Excelentiſsimo ſeñor Don Iuan Tellez
Giron, Quarto Duque de Oſſuna.

Año 1645.

En Madrid, Por Gregorio Rodriguez.
A coſta de Roberto Lorenço, vendeſe en ſu
caſa, en la Carrera de S. Geronymo.

Lope de Vega
La Arcadia (1598)

We will visited John Milton's Paradise Lost (1658) in Chapter 16, Underground Rivers in English Fiction, but here we'll mention his poem "Arcades" (1633) which drew upon the Alpheus story,

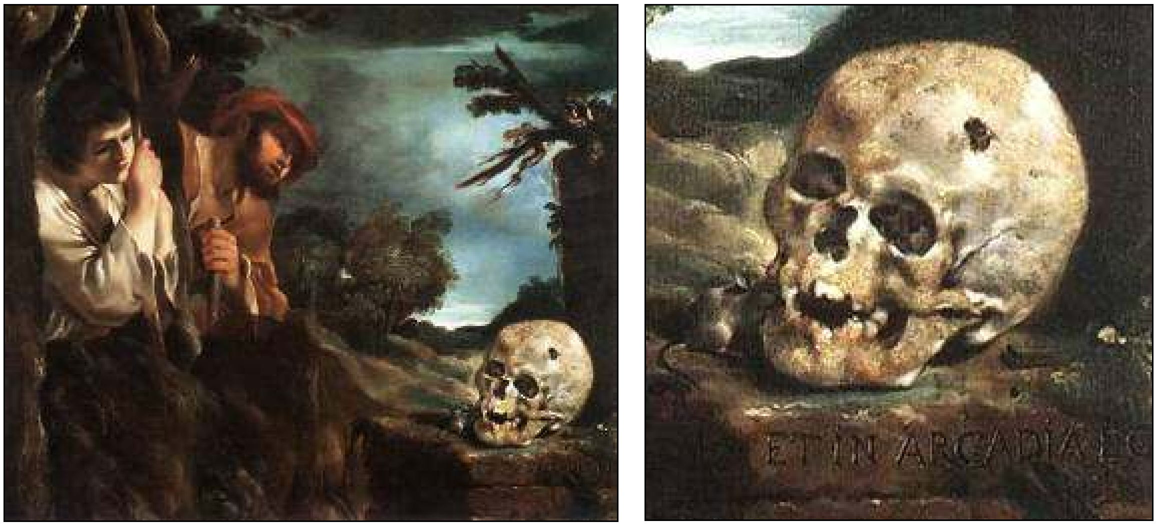
I see bright honor sparkle through your eyes;
Of famous Arcady ye are, and sprung
Of that renowned flood, so often sung,
Divine Alpheus, who, by secret sluice,
Stole under seas to meet his Arethusa;

Using the symbolic flow of water to connect Greek poetry to its descendant, Sicilian poetry, the poem recalls images of shepherds, nymphs, and pastoral landscapes, subjects with which Milton was well versed from Sidney's Arcadia.

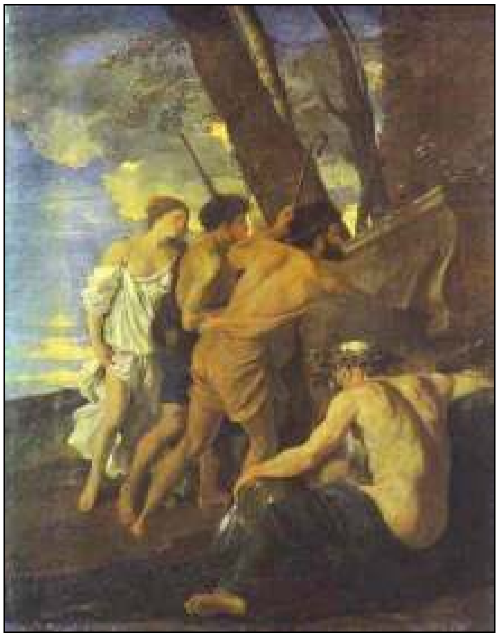
But what is pure and undefiled must eventually be corrupted by humankind. To disillusioned modern philosophers, the underground river was to more and more represent history's melancholy underpinning.

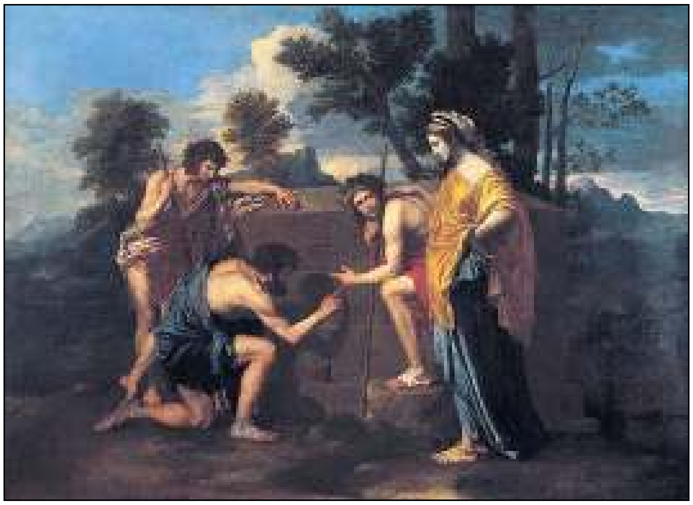
Et In Arcadia Ego

The inscription "Et In Arcadia Ego" -- "And I (death) am even in Arcadia" -- first appeared in a 1608 painting by Giovanni Barbieri. The underground river represents life's ultimate fate, often portrayed by a tombstone or a fountain.



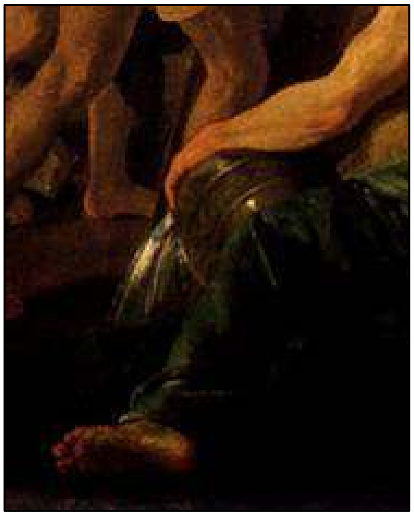
Nicolas Poussin painted two versions of Les Bergers d' Arcadie (The Shepherds of Arcadia), more commonly known as "Et In Arcadia Ego, I" and "Et In Arcadia Ego, II."





"Et in Arcadia Ego, II" (1637-1638)

"Et In Arcadia Ego, I" (1630)

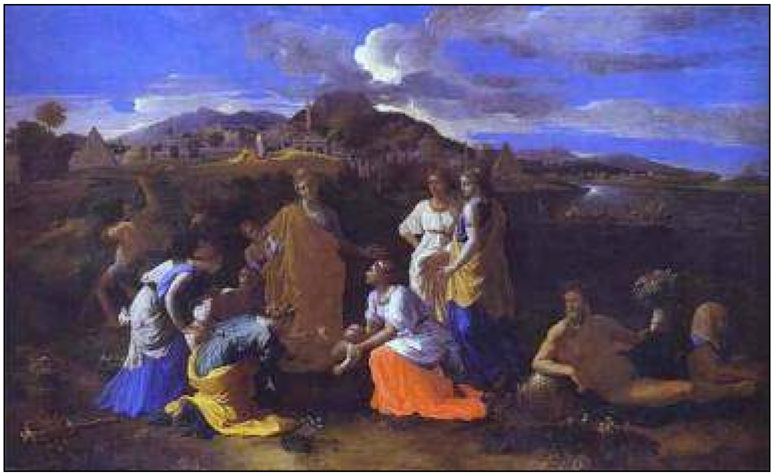


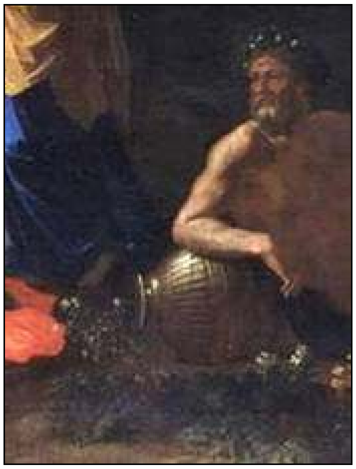
"Et In Arcadia Ego, I" depicts three men and a woman, two of the men and the woman occupied with the apparent discovery of a tomb. The inscription "Et In Arcadia Ego" seems to have an unsettling effect.

In the lower right sits the river god Alpheus, seemingly allied with nature, not culture. In his hand is an urn representing Arethusa Fountain, the flowing water suggesting the continuity of time. The god and his urn were present before this scene occurred and will be there after the drama is spent.

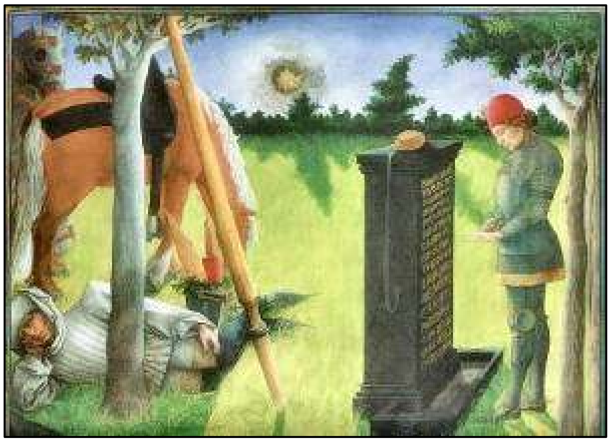
In "Et In Arcadia Ego, II," three shepherds point at the tomb's inscription, but absent is an air of melancholic contemplation. Poussin's Venetian training shows in the golden orange, scarlet, and midnight blue. The shepherds have figuratively eaten of the apple by Eve in Eden. Classical painters of the era used statuary as female models and the enigmatic female looks frozen.

Poussin was renowned for his Arcadian settings, even when the subject didn't fit, an example being that of rendering the Nile as a visual Greece in "The Finding of Moses" (1647).





The entirely-predictable focus is on women exclaiming over the discovery of the baby, but to the right, in shadow rather than highlighted and sitting rather than standing, Alpheus leans again on the spilling urn, the Arethusa Fountain. Having delivered Moses to where he will change history, the river god retreats. A sphinx stares beyond the canvas. The artist knows that unanswerable questions lie behind commandments inscribed in stone.



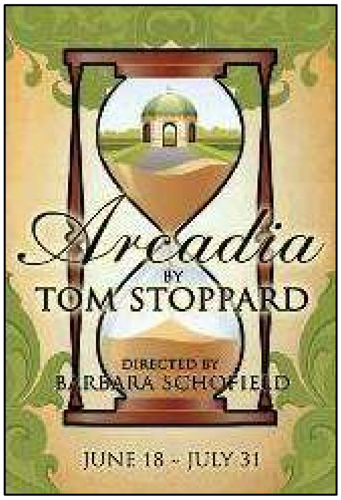
Rene d'Anjou, King of Naples (1438 -1442) and titular King of Jerusalem (1438-1480) used the theme of an underground River Alpheus to represent a subculture of Arcadian esotericism, unlike the Garden of Eden, free of Judeo-Christian constraints.

D'Anjou's Les Coeur d'Amours Espris (1457), depicted the fountain of the underground stream flowing from a tombstone.

In 1945, Evelyn Waugh sub-titled the first part of Brideshead Revisited "Et In Arcadia Ego," referring to his protagonist's blissful and innocent interbellum years as an undergraduate student at Oxford University.

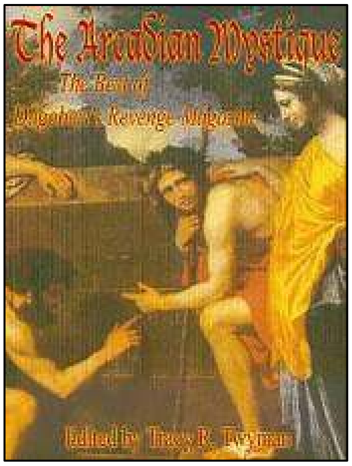
Tom Stoppard's Arcadia (1963) -- originally Et In Arcadia Ego -- involves themes of classical beauty and order in conjunction with the evolution of Western understanding of nature. Thomasina, unpretentious, innocent in youthful happiness, is the play's endearing character. Her death before cynical adulthood can destroy her in the same way that chaos will destroy the universe seems almost fortuitous.

Arcadia represents a fallen Eden, an intermingling of heavenly gifts and the folly of humanity. Et In Arcadia Ego -- The sun shines upon us, but what flows below?



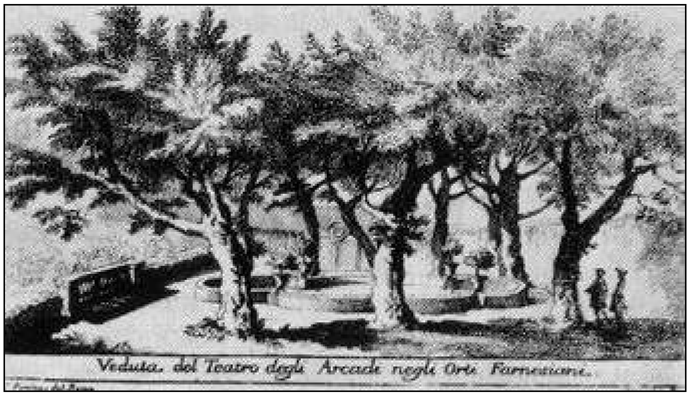
Tracy Twyman's undated "The Real Meaning of 'Et In Arcadia Ego' and the Underground Stream," The Arcadian Mistique, rolls the Arcadian tie back to the devine.

> *Interestingly the word Jah (the name of the Jewish god inside the Ark of the Covenant) comes from the name Ia, the Lord of the Earth and Lord of the Deep Waters in Sumeria on which the Hebrew god Jehovah's character is partially based... King Ia, "Lord of the Deep Waters," was often depicted with water flowing from his throne. If this throne is now located in the center of the Earth, in the underworld, as legend tells us, then it is therefore also the source of an "underground stream."*

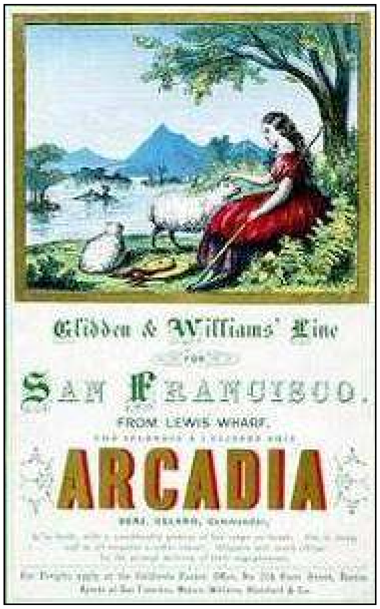


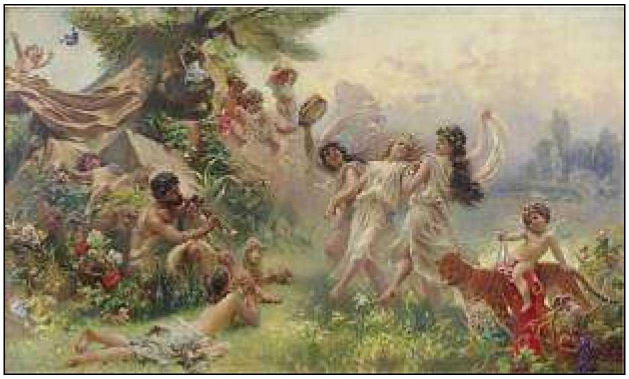
It's no light-hearted sail, this particular subterranean Alpheus.

Below are a few Arcadian pieces from later times. Three portray land as those of the early Renaissance might have envisioned it, a world of blithe innocence. Three portray the land as it would come to be interpreted, a landscape with wondrous but ominous trees, lurking deity, protentions of a future uncertain.

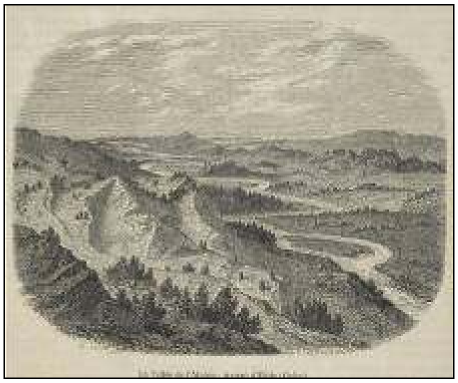

Veduta del Teatro degli Arcadi negli Orti Farnesiani.

Arcadian Landscape, undated,
but note the tri-cornered hats

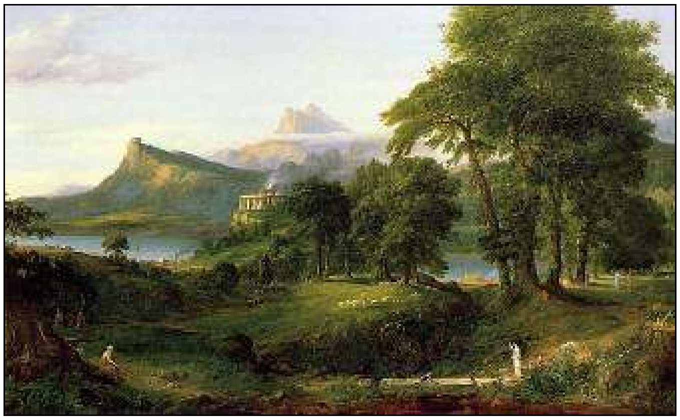

Glidden & Williams' Line
FOR
SAN FRANCISCO.
FROM LEWIS WHARF,
ARCADIA



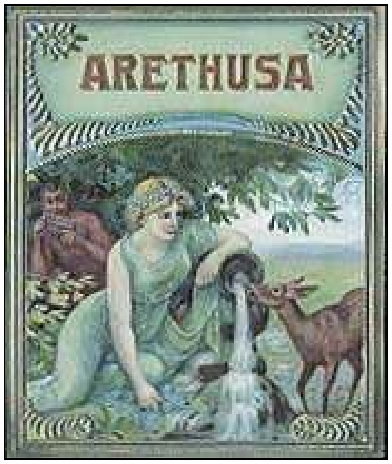
Konstantin Makovsky
"Happy Arcadia," 1890



Valley of the Alpheus, Arcadia, 1861



Tomas Cole
"The Arcadian or Pastoral State," 1836

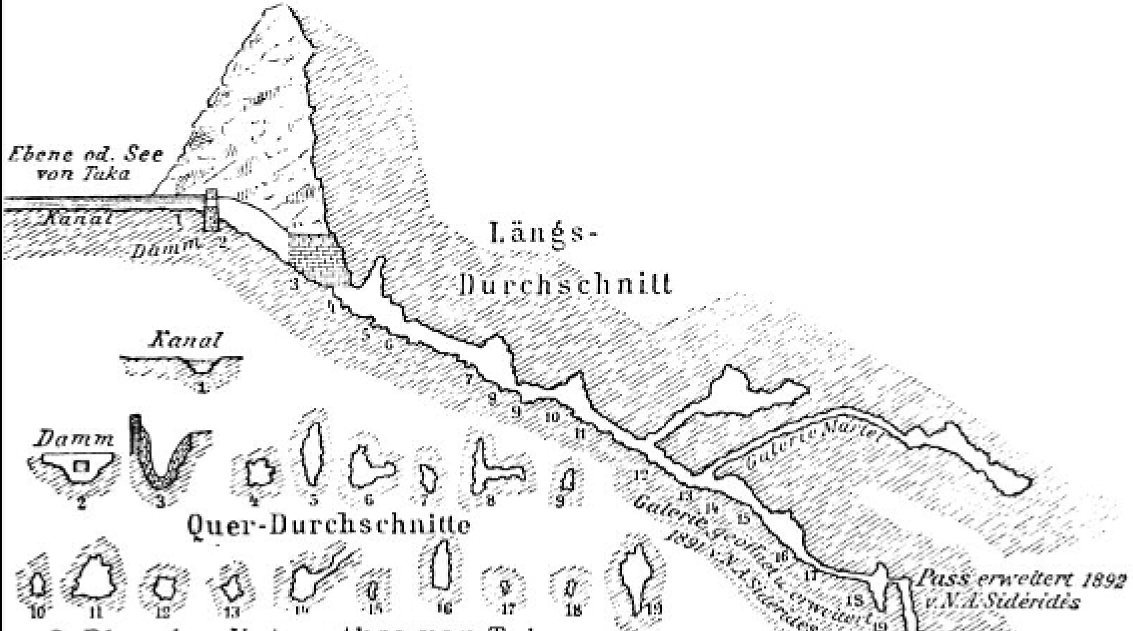


An Engineer

Few poets and painters could have personally said, "Et In Arcadia Ego," as they were working from stories. It would thus be unjust to ignore an engineer whose contribution involved actually being there.

Lake Taka on the Peloponnese Peninsula is an intermittent karst lake fed by surrounding dolines and sinks during the rainy season. It is drained by underground caves and in dry years, dries out completely.

In 1891, engineer N.A. Sideridis undertook works to better drain the Plain of Taka. The first step was to explore the Katavothres (swallow holes), accompanied by E.A. Martel whom we will encounter in Chapter 49, Subterranean Watercraft. The pair discovered a deep cave system and an underground river gorge.


Ebene od. See
von Taka
Kanal
Damm
Längs-
Durchschnitt
Kanal
Damm
Quer-Durchschnitte
Galerie Martel
Galerie geöffnet u. erweitert 1891 v. N.A. Siderides
Pass erweitert 1892
v. N.A. Sidéridès
1
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19

2. Plan der Katavothre von Taka.

Map redrawn after Martel and Sideridis, Mayers Konversations-Lexikon (1905)

Sideridis put a grid over the sink's entrance to prevent re-blockage by debris and excavated channels from the three incoming streams.

As an aside, the process of confirming the above Taka's geography unearthed reference to a like-named plain in the Sudan. From African Wanderings; or, An expedition from Sennaar to Taka, Basa, and Beni-Amer, with a Particular Glance at the Races of Bellad Sudan (1852) by Ferdinand Werne,

> *In the country of the Haddenda is one spring, which supplies nearly the half of it; there one can plainly observe how the water runs strongly below the surface, and the land of Taka is also full of such underground watercourses.*

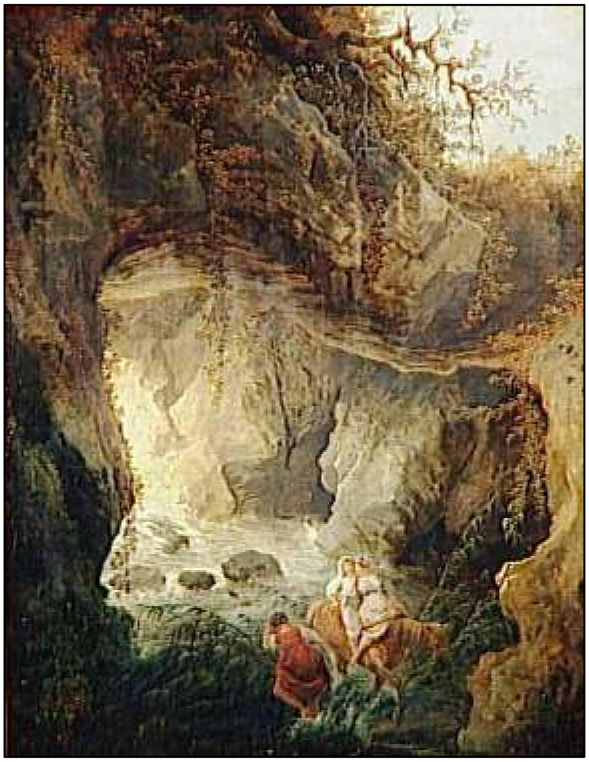
Another Taka with its own underground rivers! As we note with some regularity, such waterways seem to be everywhere.

Conclusion

There is no physical underground channel from the Peloponnese Peninsula to Sicily, but our story is less about a water pipe than it is about a conduit of culture.

An idealized Arcadia was to fuel -- and to be fueled by -- the renaissance of Western culture and we thus recall land's underground rivers.

We'll depart Peloponnese not by a submarine River Alpheus, but via the subterranean Arcadian stream in Robert Hubert's 1808 "Le Grotte" with its trio of women illuminated by the water's mysterious light.



CHAPTER 29

THE UNDERGROUND RIVER AS METAPHOR

From the Introduction,

> *A model is an expression of something we wish to understand in terms of something we think we do understand.*

This chapter looks at underground rivers not as an aspect of setting, fictional or otherwise, but as a literary instrument in which some combination of

"Underground" "Subterranean" etc.	+	"River" "Steam" "Waters" etc.

occupies the second clause of modeling's two-clause definition.

Insertion of the adverb "like" or "as" changes a metaphor into a simile,

> Such-and -such is an underground river -- a metaphor,
> Such-and -such is like an underground river -- a simile,

but both are said to be metaphoric. In quotations to follow, we'll highlight the underground river clause in CAPITAL LETTERS.

We'll begin with three explanations of our metaphor.

> *It has been noted as the peculiar characteristic of our time, that old institutions are continually giving way to new opinions, and that things of antiquity have "fallen on evil days." Such has not been the case with the Lumber Troop: -- to make use of a new simile, their course has been like that of an UNDERGROUND STREAM till now, when Sir John Key has discovered all their merit, and brought them before the wondering world in such a way that nobody can tell the importance or the consequence thereof.* -- Edward Brewster, The Lumber Trooper: A Chivalric Poem, Written After the Most Approved Models (1832)

The simile wasn't in fact "new" in 1832, but apparently it wasn't hackneyed.

From the contemporary internet,

> *As a British Venus, Goddess of Gardens, she is the Flower Bride; at her Holy wells, mainly to be found in the North of the country, she is guardian of the underground streams that carry the sacred waters. These UNDERGROUND STREAMS have themselves become a metaphor for the secret continuation of sacred wisdom.* -- Caroline Wise, "Elen of the Ways," internet posting, 2009

> *Humans have always drawn on a rich UNDERGROUND RIVER of subconscious wisdom, which sometimes emerges as metaphors, fairy tales, fables, myth, legends, or Holy Scripture.* -- Jeanne M. Wiger, LedToGold.com internet posting

Following are underground river metaphors and similes excerpted from a variety of sources. To group them, we suggest interpretations, but the creative merit of the construction is that the meaning ultimately rests with the reader.

Anger

> *It has become an UNDERGROUND RIVER, this populist anger about the effects of economic globalization.* -- "One World, Ready or Not, The Manic Logic of Global Capital," Washington Monthly, April 1997

Art

I think that visual art is part and parcel of many people, another UNDERGROUND STREAM flowing through their life. The more you learn to see, the more you can tap into the UNDERGROUND STREAM. -- Jeannine Cook, "Art, an UNDERGROUND STREAM flowing through life," internet posting, 2009

Belief

Mr. Thompson's feel for the tangle of beliefs and resentments in the "the UNDERGROUND RIVER of New Age ideas" is exemplary. -- "The End of Time, Faith and Fear in the Shadow of the Millennium," The Economist, December 7, 1996

Being

The musicality of being is the silence which holds all knowledge.
It is the quiet pool at twilight, free of ripples and full with the moon's reflection.
It is the breathing of a quiet forest, whose creatures are at rest.
It is the water of an UNDERGROUND RIVER, which flows towards the sunlight.
It is the perfect white vase, empty yet full. -- The Shakti of Aksobhya (Buddhist)

Communication

The power to communicate thought is nearly as important as thought itself. What is more vain than for a man to draw from the clear mountain springs of knowledge, and then flow through the world, a SUBTERRANEAN STREAM? -- P.E. More, An Apostrophe (1897)

Connection

They speak to us of the UNDERGROUND RIVERS that connect us, building a foundation of relationships at the center of our processes -- Michelle LeBaron, Bridging Troubled Waters, Conflict Resolution from the Heart (2002)

Biography, even autobiography, is full of systemic error, of holes that connect like a tangle of UNDERGROUND STREAMS. -- Carol Shields, The Stone Diaries (1994)

Consciousness

Think of it like a tree whose roots go down deep and tap into our ultimate source -- an UNDERGROUND RIVER of soul consciousness that exists beyond time and space and also beneath our deepest fears (the unified Field). -- Allen L. Roland, "Newsletter, Spirituality," internet posting, June 2001

Constance

Of deeper import still, like an UNDERGROUND RIVER, there ran a limpid flow of native songs attuned to the genius of the people. -- K.M. George, Western Influence on Malayalam Language and Literature (1972)

Yet throughout the twenty-four songs and seventy-two slokas, the thread of deep devotion runs like a SUBTERRANEAN STREAM. -- Subas Pani, "A Two-Part Study of Jayadeva's Glorification of Sri Krsna in His Jagannatha Manifestation," internet posting, 2009

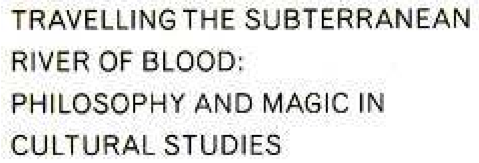
The conception of the cosmos as the mechanism of self-expression for the infinite has flowed through all ages of thought LIKE A SUBTERRANEAN STREAM. -- Helen F. Dunbar, Symbolism in Medieval Thought and Its Consummation in "The Divine Comedy" (1929)

"German Art in the 20th Century," the huge show of some 300 works by 52 artists that has been the talk of London since it opened at the Royal Academy in October, has a clear agenda. It wants to prove something, and that something is continuity, from 1905 to 1985... The image stream of German expressionism went UNDERGROUND, but not even Nazism could dry it up. It is the deep, continuous current of German modernism. -- Robert Hughes, "Tracing the Underground Stream. In London, a Major but Uneven Survey of German Modernism," Time, December 23, 1985

Convergence

What history has shown is that eventually these UNDERGROUND STREAMS do alter the balance of power of the world. -- Philip Gardiner, Secret Societies, Gardiner's Forbidden Knowledge (2007)

Where is the unity, the meaning, of nature's highest creation? Surely those millions of little streams of accident and willfulness have their correction in the vast UNDERGROUND RIVER which, without a doubt, is carrying us to the place where we're expected! -- Tom Stoppard, The Coast of Utopia (2002)


TRAVELLING THE SUBTERRANEAN
RIVER OF BLOOD:
PHILOSOPHY AND MAGIC IN
CULTURAL STUDIES

The SUBTERRANEAN RIVER of blood story is about the bodies of the participants collectively joining the flows of their life forces, their blood, to create a fluidity which dissolves all borders (between their individual bodies and the sacred ground, the ground made sacred).

The exfoliation is almost absolute, but it retains these features: vitality, movement, transformation (the bodies return to normal when they re-emerge). -- Stephen Muecke, "Travelling the SUBTERRANEAN RIVER of Blood: Philosophy and Magic in Cultural Studies," Cultural Studies 13:1, 1999

Creativity

Forget writing, it's a trivial matter. But day in day out, when the inarticulate patient struggles to lay himself bare for you, or with nothing more than a boil on his back is so caught off balance that he reveals some secret twist of a whole community's pathetic way of thought, a man is suddenly seized again with a desire to speak of the UNDERGROUND STREAM which for a moment has come up just under the surface. It is just a glimpse, an intimation of all that which the daily print misses or deliberately hides, but the excitement is intense and the rush to write is on again -- William Carlos Williams, The Autobiography of William Carlos Williams (1951)

What he is trying to do is jump-start a poem by lowering a bucket down into a kind of UNDERGROUND STREAM flowing through his mind -- a stream of continuously flowing poetry, or perhaps poetic stuff would be a better way to put it. Whatever the bucket brings up will be his poem. -- Larissa MacFarquhar on John Ashbery in "Present Waking Life," New Yorker, November 7, 2005

The UNDERGROUND RIVER of creation curves on beneath the surface life, its inspiring waters ever available to refresh and bring sparkle to daily life. People who feel that they are uncreative often complain that they do not know how to get access to these waters. Surely, these people assert, creative waters run through particularly gifted people only. -- "The Underground River of Creation Revisited," Beth Owl's Daughter, internet posting, March 2010

Culture

Cultures flow through our lives like UNDERGROUND RIVERS, powerfully nurturing, potently influencing, and sometimes dividing -- Michelle LeBaron, Bridging Cultural Conflicts (2003)

How bright, in comparison, the conception of our personality, meandering like an UNDERGROUND RIVER through the hidden world of God's creation, and enabling us, at each stage, to partake of Humanity's victories. -- Laurence Gronlund, Our Destiny, The Influence of Socialism on Morals and Religion (1891)

Culture is the UNDERGROUND STREAM of norms, values, beliefs, traditions, and rituals that builds up over time as people work together, solve problems, and confront challenges .This set of informal expectations and values shapes how people think, feel, and act in schools. -- T.E. Deal and K.D. Peterson, "How Leaders Influence the Culture of Schools," Educational Leadership, September 1998

Destiny

Surely those millions of little streams of accident and willfulness have their correction in the vast UNDERGROUND RIVER which, without a doubt, is carrying us to the place where we're expected! -- Tom Stoppard, The Coast of Utopia (2003)

Distance

He stopped and laughed--a low, gurgling laugh--and it was to the girl like the roar of some SUBTERRANEAN RIVER heard from afar. -- Edgar Wallace, The Book of All-Power (1921)

Dormancy

Using the UNDERGROUND RIVER as a metaphor for all that lays dormant in our exceedingly domesticated society; Something About a River explores various angles on the notion of ambivalence. -- review of Bluemouth, Inc's "Death by Water" from the trilogy "Something About a River," Fort Greene Park Conservancy internet posting, 2008

Far too antiauthoritarian to brook fuehrers or gurus, Pagans use historical materials to cure themselves of historical determinations, and to tape the UNDERGROUND STREAMS murmuring beneath the dominant narratives of the patriarchal state. -- Erik Davis, "Remains of the Deities, Reading the Return of Paganism," internet posting

Emergence

In relation to his public, the artist of today is like the speleologist of the Peak or of the Causses of Southern France; he walks at first with his companions, till one day he falls through a hole in the brambles, and from that moment he is following the dark rapids of an UNDERGROUND RIVER which may sometimes flow so near to the surface that the laughing picnic parties are heard above, only to re-immerse itself in the solitude of the limestone and carry him along its winding tunnel, until it gushes out through the misty creeper-hung cave which he has always believed to exist, and sets him back in the sun. -- English literary critic Cyril Connolly, The Condemned Playground (1946)

1st
First Place
Underground River
Metaphor

The award's only our opinion, of course, but we think it's deserved

It was as if an UNDERGROUND STREAM flowed through the country and broke out in sudden springs that shot to the surface at random, in unpredictable places. -- Ayn Rand, Fountainhead (1943), describing hero Howard Roark's struggle and success

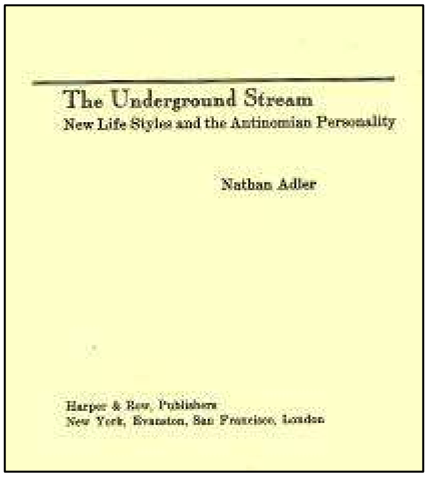
The "well of life'" is not in the next world, and not in the church's font; it is in human beings themselves. If they receive the life-giving water, they themselves become the wellspring of this water for other people. With this as background, Meister Eckhart painted the picture of God -- the Spirit of life -- as a great UNDERGROUND RIVER which rises to the surface in the springs and fountainheads. -- Jürgen Moltmann, The Spirit of Life, A Universal Affirmation (2001)

The SUBTERRANEAN STREAM of Western history has finally come to the surface and usurped the dignity of our tradition. This is the reality in which we live. And this is why all efforts to escape from the grimness of the present into nostalgia for a still intact past, or into the anticipated oblivion of a better future, are vain. -- Hannah Arendt, The Origins of Totalitarianism (1950)

There are UNDERGROUND STREAMS that flow on unseen and at length reappear to the light of day, holding on their course with undiminished volume. In like manner do the streams of influence disappear from view only to rise again, oftentimes when least expected, hewing their

> *rocky way over the barriers of time or watering the broad valley till it smiles anew in an Eden bloom.* -- "Editor's Table," Harpers Magazine, August 1858
>
> *Everything lies in everyone of us, but has to be brought to the surface. It grows a little in one, more in that one's child, more in that child's child, and so on and on -- with curious breaks as of a river which every now and then takes to an UNDERGROUND COURSE.* -- George MacDonald, The Flight of the Shadow (1891)
>
> *Among literary scholars, interest in the Bible during the first three quarters of the twentieth century can be pictured as an UNDERGROUND STREAM that finally came to the surface around 1960.* -- Leland Ryken and Tremper Longman, eds., The Complete Literary Guide to the Bible (1993)
>
> *Neo-Platonism may be compared to an UNDERGROUND RIVER that flows through European history, sending up, from time to time, springs and fountains; and wherever its fertilizing stream emerges, there imaginative thought revives, and we have a period of great art and poetry.* -- Kathleen Raine, Blake and Antiquity (1979)
>
> *Cather implies a sharp contrast between the now of Marie's passions and that of Alexandra's, whereas Alexandra keeps the "UNDERGROUND RIVER" of her inner life safely hidden below the surface of her consciousness, so that it can continue to feed her art, Marie lets the river of her emotions rise up to the surface, only to drain her inner wellspring.* -- Demaree C. Peck, The Imaginative Claims of the Artist in Willa Cather's Fiction (1996)
>
> *The great excitement of Great Expectations -- and it is still there, on the screen -- has to do with the rediscovery that visual storytelling was not just a notional link between Charles Dickens and movies, but an UNDERGROUND RIVER that had broken above ground.* -- The Guardian, January 23, 2007, review of the movie Great Expectations (1997)
>
> *And language bubbled out of place as a spring from UNDERGROUND STREAMS the soil concealed.* -- Meena Alexander, "Poetry, The Question of Home," internet posting, Academy of American Poets, 2009
>
> *No matter how insistently scholars and metaphysicians wave their dowsing wands, the sources of creative artistry remain largely undiscovered. Secret UNDERGROUND RIVERS of imagination can bubble up at unexpected times and places. If the geology of talent were a completely developed science, it might explain George Crumb to us.* -- Donal Henahan, "Review/Music, Helping George Crumb Celebrate His Birthday" -- New York Times, October 26, 1989
>
> *And like an UNDERGROUND RIVER, it waits for the right moment (an event or transition) to resurface in the form of beliefs, fantasies, and actions. It is here, where it breaks the surface of life, the intergenerational transference has to be caught unawares, challenged, acknowledged, revised, and sent on its way.* -- Vittorio Cigoli and Eugenia Scabini, Family Identity, Ties, Symbols, and Transitions (2006)
>
> *Was this -- like the emergence of some UNDERGROUND RIVER -- the musical reincarnation of impulses subconsciously remembered from generations earlier and producible only when the carrier of this memory had developed his instrumental technique sufficiently to cope with it?* -- "The New Grove Dictionary of American Music," The Atlantic Monthly, March 1987
>
> [Quentin's relived present] *moves along in the shadow, like an UNDERGROUND RIVER, and reappears only when it itself is past*. -- Jean-Paul Sartre, "On The Sound and the Fury, Time in the Work of Faulkner," Literary and Philosophical Essays, 1955

Nathan Adler uses the term "antinomian" to designate opposition to customary moral obligations. The Underground Stream, New Lifestyles and the Antinomian Personality (1972) is an effort to explain culture of LSD.



The Underground Stream
New Life Styles and the Antinomian Personality

Nathan Adler

Harper & Row, Publishers
New York, Evanston, San Francisco, London

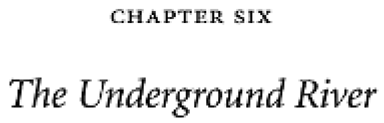
> *I discuss some of the newer therapies as an expression of the same antinomian orientation that surfaced in the hippie culture from the enduring UNDERGROUND STREAM.*
>
> *The history of that UNDERGROUND STREAM and of the antinomian personality who rides it is a long-term study.*

and

> *The gnostic values ran like an UNDERGROUND STREAM, this stream disappeared as society became tranquil and stable, but in stressful times the antinomian values surfaced again and became stronger.*

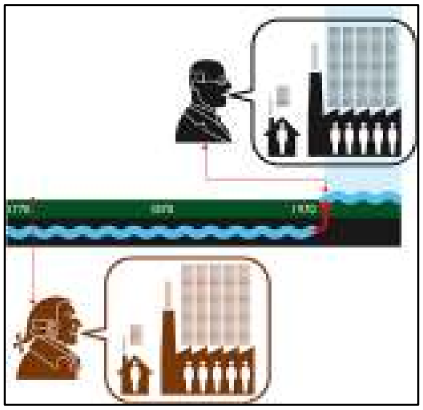
Since the heady days of 1972, however, the antinomian Flower Power subterranean river has largely resubmerged into a cloud of illicit smoke.

Or without the use of words, the re-emergence of Adam Smith in David Warsh's A Story of Economic Discovery (2006)



CHAPTER SIX

The Underground River



Emotion

> *Our history has moved us on two rivers, one visible, the other underground; there has been the history of politics which is concrete, practical, and unbelievably dull... and there is the SUBTERRANEAN RIVER of untapped, ferocious, lonely and romantic desires, that concentration of ecstasy and violence which is the dream life of the nation.* -- Norman Mailer, "Superman Comes to the Supermarket," Esquire, November 1960, about John F. Kennedy

Erosion

> *Because of this latter fact particularly, while prostitution in peacetime is like some treacherous UNDERGROUND STREAM slowly washing away the solid earth, in times of national crisis like the present, unless firmly curbed, it may become like a raging torrent, damaging the health of our armed forces and workers in industry to an extend of affecting the war's outcome.* -- J.B. Pinney, "How Fares the Battle against Prostitution?" Social Service Review 16:2, June 1942

Esoteric

> *There have been many hypotheses written about the final destination of the treasures of the Templars, some even pointing to the New World!... But it is far more likely that the quickest, shortest and safest destination was -- England. The English King was a staunch ally of the Templars -- he was the only one who stuck with his protests -- and besides, such a scheme had already worked once before in 1247. One might add that Arsene Lupin later explained how the use of the secret UNDERGROUND RIVER and the hidden fortress of the Hollow Needle may have helped made such a scheme feasible.* -- The French World Newton Universe, "Will There

be Light Tomorrow? The History of the Greatest Conspiracy Man Has Ever Known," internet posting

The "UNDERGROUND STREAM," the hidden mysteries of western esotericism. From Merlin to Nostradamus, from Parzival and the Holy Grail to Alchemy and the mystery of the cathedrals, from the origins of the Tarot cards to the Hebrew/Druidic /Arthurian cabala, most of the major currents flowing through the UNDERGROUND STREAM surface, or have their origin, within a few miles of the lost Roman city of Glanum.... From the answers to these question arise a vast untold story of the UNDERGROUND STREAM in the west, from Jason and the Argonauts to the Gnostic Christians, the Cathars and the legends of the Holy Grail, down to the true identity of the Knights of the Rosy Cross. -- Weidner and Vincent Bridges, The UNDERGROUND STREAM and Fulcanelli's Message, 1888

Experience

In all melodrama, heightened emotion and exaggerated gestures or, in the case of television, extended camera play on facial expressions represent the invisible life, the SUBTERRANEAN RIVER of experience. -- Mary S. Mander, "Dallas: The Mythology of Crime and the Moral Occult," Journal of Popular Culture 17:2, Fall 1983

Faith

Faith in the immortality of the soul exists deep down in their own souls like a SUBTERRANEAN RIVER, neither seen nor heard, but watering the roots of their deeds and their motives. -- Miguel de Unamuno, Tragic Sense of Life (1921)

Fear

You are walking in a dark cave, a vast subterranean string of passageways, unmapped. You have both a lantern and torch and you're an experienced explorer. There's a sense of joy, then. Caution, wisdom, but joy, in your exploration. As you move around a sharp corner, suddenly the ground gives way beneath you and you begin to slide. You drop your lantern, you drop your torch; your hands reach out trying to grab some surface to try to stop the slide. You find yourself falling literally into space and then splash! You are in cold water. Deep water. Moving water. -- "Wednesday Evenings with Aaron at Deep Spring Center," internet posting, May 3, 2000

Foundation

The editors have been deeply attracted to the vivid movement and activity of his poetry, which seem to flow up from an UNDERGROUND RIVER that lies beneath mere speech, as though written in some pre-verbal language of which all later languages have proved to be a mere translation. -- Peter Davison, "A Reflection on Poet W.S. Merwin," Atlantic Monthly, August 28, 1997

Proceedings of the Grand Lodge of Free and Accepted Masons of the State of New York (1917)

Q: What was Freemasonry prior to the London Conference of 1717?
A: An UNDERGROUND RIVER, with tributaries in widely scattered sections of Great Britain.

Hidden

My life is like the SUBTERRANEAN RIVER in the Peak of Derby, visible only where it crosses the celebrated cavern. I am here, and this much I know; but where I have sprung from, or whither my course of life is like to tend, who shall tell me? -- Sir Walter Scott, Redgauntlet (1824)

The work an unknown good man has done is like A VEIN OF WATER FLOWING HIDDEN UNDERGROUND, secretly making the ground green. -- Thomas Carlyle, Essays -- Varnhagen von Ense's Memoirs (1838)

> *Once, in my travels, I saw a whole river disappear under ground, and, miles below, it reappeared. The surface of the country, however, gave no evidence that a river was rolling beneath, no more than the faces of some present, while conviction for sin, like that SUBTERRANEAN RIVER, is rolling through their heart. I have known enough of people during and after a revival, and sufficiently of some present, to warrant me in making a very pointed application of the same.* -- Arrows from my Quiver: Pointed with the Steel of Truth and Winged by Faith and Love Selected from the Private Papers of Rev. James Caughey (1868)

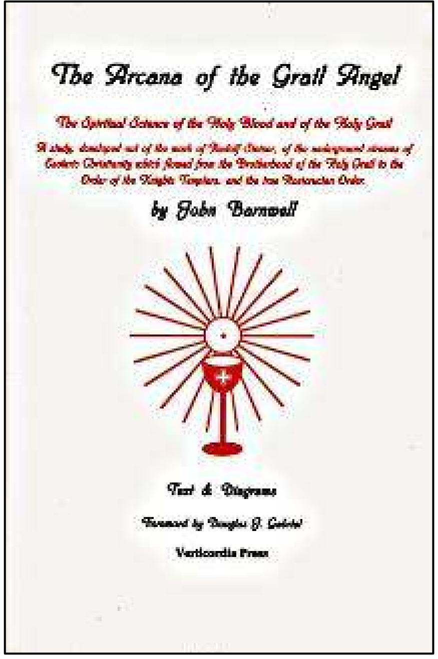
> *In this National Council of Women... we have only another illustration of the outreach of human hearts toward each other and toward humanity, stimulated by the almost universal desire to better the conditions of human life for the suffering of the children of men... The desire had been hidden like an UNDERGROUND STREAM from the day when Miriam first gathered women together to dance to the sound of the timbrel and to "sing to the Lord a new song."* -- Mary Lowe Dickinson, The Arena, February 1897

> "*It's an UNDERGROUND RIVER of money," says John Davis of State Affairs. "It's very hard to find. And it's absolutely legal." -- "Attorneys' Rising Political Clout (Political Donations to Judges by Plaintiffs' Lawyers),"* Nation's Business, February 1998

Holy Blood

> *The motif of an UNDERGROUND STREAM seems to have been extremely rich in symbolic and allegorical resonances. Among other things, it would appear to connote the "underground" esoteric tradition of Pythagorean, Gnostic, Cabalistic, and Hermetic thought. But it might also connote something more than a general corpus of teachings, perhaps some very specific factual information -- "secret" of some sort transmitted in clandestine fashion from generation to generation. And it might connote an unacknowledged and thus 'subterranean' bloodline.* -- Michael Baigent, Richard Leigh and Henry Lincoln, Holy Blood, Holy Grail (1982)

For those anxious about such conspiracies, may we suggest The Arcana of the Grail Angel, The Spiritual Science of the Holy Blood and of the Holy Grail, A Study developed out of the work of Rudolf Steiner of the UNDERGROUND STREAMS of Esoteric Christianity which flowed from the Brotherhood of the Holy Grail to the Order of the Knights Templars and the True Rosicrucian Order (1999) by John Barnwell.


The Arcana of the Grail Angel
The Spiritual Science of the Holy Blood and of the Holy Grail
by John Barnwell
Text & Diagrams
Foreword by Douglas J. Gabriel
Verticordia Press

Inevitability

> *Even as an enormous UNDERGROUND RIVER of people flows south to north across the American continent -- the vast human tide of illegal immigration from Mexico flowing north across the Rio Grande -- it is counterbalanced almost perfectly by another vast UNDERGROUND RIVER flowing north to south: a flow of capital, in remittances from workers back to their families at home.* -- Affordable Housing Institute, internet posting, June 8, 2007

> *But where was that free money coming from that these tubabs kept pulling from their pockets? It was like there was a money spring welling up in that cold country. Like a RIVER UNDERGROUND washing up all the money from the world out onto the flood plains of the old River Thames... The River Gambia never worked like that; it washed people out to other lands and sometimes it brought villagers from upcountry to Baku looking for a new life in the tubab hotels. But not money. No, never money.* -- Richard Tromans, The River Underground (2003)
>
> And Tromans' closing line, the protagonist being handcuffed. *Hus felt like he was floating, floating up from an UNDERGROUND RIVER.*
>
> *Notwithstanding the silencing of the Legal Realists in the course of the Second World War, the resonance of their critiques of conceptual and rule formalism continued like a SUBTERRANEAN RIVER.* -- Brian Z. Tamanaha, "How an Instrumental View of Law Corrodes the Rule of Law," DePaul Law Review 469, 2006

Margaret Atwood's factual allusion to underground rivers (see Chapters 40, Sinkholes, and 64, Minewaters) provides metamorphic correspondence.

> *I think of those towns built on UNDERGROUND RIVERS, where houses and whole streets disappear overnight, into sudden quagmires... Something like this must have happened to her, once she saw the true shape of things to come.* -- Margaret Atwood, The Handmaiden's Tale (1986)

Although it's a bit longer, we can't leave out Hemingway's Boat: Everything He Loved in Life, and Lost, 1934-1961 (2011) by Paul Hendricksonis.

> *Here's another example of the UNDERGROUND RIVER of Hemmingway fatalism:*
>
> *Not so long after Arnold Samuelson knocked at is door -- about three months later, by my calculation -- in Cuba, with his boat,*
>
> > *remembering Africa,*
> > *remembering Spain,*
> > *remembering a car wreck and fractured arm out West,*
> > *remembering a forward listening post on the Piave front in World War I when he was a teenager,*
>
> *the mentor wrote:*
>
> > *"I did nothing that had not been done before me. I had been shot and I had been crippled and gotten away. I expected, always, to be killed by one thing or another and I, truly, did not mind any more."*

Influence

> [Astrology's] *impact on history and on the history of ideas, an UNDERGROUND RIVER through human affairs.* -- Benson Bobrick, The Fated Sky (2005)
>
> *Yet the more one reads Beckett, even late Beckett, the more one realizes that the intensity of emotion is still there, only in a new form, albeit formless, but there nevertheless, like an UNDERGROUND RIVER rippling the stylized surface of the written page.* -- Corina Martin-Jordache, "Modernity, Urban Semiology and the Beckettian Cityscape," Journal of European Studies, December 2002

Inspiration

> *Like an UNDERGROUND RIVER flowing through Western culture, the Greek gods have sent up springs and fountains, inspiring and fertilizing the Western imagination for more than twenty centuries.* -- Arianna Huffington, inside flap, The Gods of Greece (1993)
>
> *Art is an act of tuning in and dropping down the well. It is as though all the stories, paintings, music, performances in the world live under the surface of our normal consciousness. Like an UNDERGROUND RIVER, they flow through us as a stream of ideas that we can tap down into.*

As an artist, we drop down the well into the stream. We hear what's down there and we act on it -- more like taking dictation than anything fancy having to do with art. -- Julia Cameron, The Artist's Way, A Course in Discovering and Recovering Your Creative Self (1992)

Life

She took solace in the impersonal life that flowed through her LIKE AN UNDERGROUND STREAM... the life that generated babies, and ate away voraciously at all organic life, and animated the wind in the trees, and made her heart beat... without her consent or understanding. -- Joyce Carol Oates, I Lock My Door upon Myself (1990)

Multiplicity

There is one UNDERGROUND RIVER -- but there are many wells into that river: an African well, a Taoist well, a Buddhist well, a Jewish well, a Muslim well, a goddess well, a Christian well, and aboriginal wells. Many wells but one river. -- Matthew Fox, Meditations with Meister Eckhart (1982) commenting on *"Divinity is an UNDERGROUND RIVER that no one can stop and no one can stop."* -- Meister Eckhart (1260-1327)

Mystery

Music is like an UNDERGROUND RIVER… You don't know where it comes from and you don't know where it's going… What I have been content with is to see music as a mystery, and I leave it at that. -- Philip Glass, composer

Nutrition

Unknown to many, Ecstasy has a less recreational, more medicinal history. In the 1970s and 1980s, the chemical known as MDMA (methylenedioxymethamphetamine, or N-methyl-3,4-methylenedioxyphenylisopropylamine) was used secretly by a select group of psychiatrists and therapists in the United States and Europe... When I learned about MDMA, I realized that this was an extraordinary situation in which there was a semisecret UNDERGROUND RIVER that was nourishing the psychedelic community. -- Julie Holland, Ecstasy, The Complete Guide : A Comprehensive Look at the Risks and Benefits (2001)

Sparks are those ideas that catch the light, inviting us into remembrances, explorations, and connections with those UNDERGROUND RIVERS that nourish us. -- Michelle LeBaron, Bridging Troubled Waters, Conflict Resolution from the Heart (2002)

Obscurity

Let me hold my course in silence for a while, and in obscurity, like a SUBTERRANEAN RIVER; the time shall come that I will burst forth in my strength, and bear all opposition before me. -- Sir Walter Scott, Kenilworth (1821)

Permeation

An UNDERGROUND RIVER of filth... ran under the city. There was no turning back. I had to wade the excremental river. -- Ross Macdonald, The Moving Target (1949), the first Lew Archer mystery

Beneath the landscape of trends and school and movements run UNDERGROUND STREAMS of sympathy and influence -- J.D. McClatchy, The Vintage Book of Contemporary American Poetry (2003)

A poet who *"engages the UNDERGROUND STREAM of our lives."* -- Peter Davison on W.S. Merwin, Boston Globe poetry editor

Persistence

Yet that was far from the end of the Neoplatonist current, that half-UNDERGROUND RIVER that has often divided as it sought new channels and is yet to run dry. -- Robert S. Ellwood, Islands of the Dawn, The Story of Alternative Spirituality in New Zealand (1993)

> *His trinitarianism ran like a SUBTERRANEAN RIVER throughout his career as a pastor and polemicist; it did not dominate his public discourse.* -- Amy Plantinga Pauw, The Supreme Harmony of All: the Trinitarian Theology of Jonathan Edwards (2002)

> *Nathaniel Hawthorne laid open a powerful UNDERGROUND STREAM in "The Scarlet Letter" - one in which desire and shame converge.* -- Cate McQuaid, Boston Globe, October 10, 2004

> *Nevertheless, the UNDERGROUND STREAM was there, and it was because she had so much personality to put into her enterprises and succeeded in putting it into them completely that her affairs prospered better than those of her neighbors.* -- Willa Cather, O Pioneers! (1913)

Power

> *There are great reservoirs of spiritual energy waiting to be tapped. If the architects of American morale are aware of this UNDERGROUND RIVER of power and idealism, tremendous things may be achieved in our time.* -- M. Griesser , "Underlying Factors in Democratic Morale," Journal of Educational Sociology 15:7, 1942

> *We feel the flow of thought, its power like an UNDERGROUND RIVER finding its way for the first time through some shifted ground -- even if he doesn't know where it will come out.* -- Robert Bly, Neruda and Vallejo, Selected Poems (1993)

> *The feeling I get when I write is akin to dropping through a trap door into the flow of an UNDERGROUND RIVER, I stand in the current and just as a plant absorbs nutrients and energy from its surroundings, I absorb the energy of this SUBTERRANEAN RIVER through my soul. This is not willed, it simply happens.* -- Karen Hesse, author of Wish on a Unicorn (1991)

Rage

> *It is not, though, and anyone with a sense of recent film history can see Thelma & Louise in the honorable line of movies whose makers, without quite knowing what they were doing, sank a drill into what appeared to be familiar American soil and found that they had somehow tapped into a wild- rushing SUBTERRANEAN STREAM of inchoate outrage and deranged violence.* -- Richard Schickel, Elizabeth L. Bland, Sally B. Donnelly and Martha Smilgis, "Gender Bender Over Thelma & Louise," Time Magazine, June 24, 1991

Replenishment

> *He rules in exile like a king who hides in public and writes nothing down. He replenishes his sources from an UNDERGROUND RIVER that is the home of the most hardy fishes. He lives in the mind like a lover in the attic who won't come down, who needs everything brought to him in order to survive. He talks on the phone to the mind with whom he quarrels and then hangs up without saying good bye. He works out all day on a secret track. Is vain, vain, vain in short short shorts.* -- Chard DeNiord, "Eros," The American Poetry Review, September 1, 2007

> *Mem, as the sign of Miriam, leads us to sing and praise God for our survival up to this point. We've made it through some deep waters. Our struggles aren't over yet, but we're still alive! Mem also reminds us that deep wells exist of which we may not be aware. Hidden, ancient UNDERGROUND STREAMS fill these wells. When we find them and dip our buckets, we tap into those deep currents of life.* -- Richard Seidman and Lawrence Kushner, The Oracle of Kabbalah, Mystical Teachings of the Hebrew Letters (2001)

Sightless

> *The memory that forsakes the sunlight, like the fishes in the UNDERGROUND RIVER, loses its eyes; the cloud of its grief carries no rainbow; behind the veil.* -- George MacDonald, St. George and St. Michael (1876)

Spirituality

An underground river can be seen as cause.

> *If; for example, you live in Australia, you may naturally wish to weave into your shamanic practice the landforms that you see in the course of your daily life, and you may know some of the dream songs told by the Aborigines. The cosmic and natural forces that created the landscape -- UNDERGROUND RIVERS, storms, earth upheavals, and so forth -- are the creative Ancestors who imbued the land with the life force that has allowed the people to live there happily for more than 100,000 years.* -- Thomas Dale Cowan, Shamanism as a Spiritual Practice for Daily Life (1996)

An underground river can be interpreted as effect.

> *Having a natural affinity with female consciousness, her [the moon, the "Queen of the Night Sky"] timeless presence profoundly affects the ocean's tidal flow, UNDERGROUND STREAMS, weather conditions, body fluids, menstruation, conception, pregnancy, childbirth, menopause and physical death.* -- Roslyne Sophia Breillat, "Lunar Mystery, Woman and the Moon," internet posting

An underground river can be a sermon, as seen in the bulletin of Trinity Assembly of God, Mt. Morris, Michigan.

January 24, '10 10:30 am
Underground Streams
"The Power of Spoken Prayer"

An underground river can feed our spiritual insteps.

> *Let the Earth energy flow in through your rootlets, effortlessly. Let it move up, up . . . up through the reaches of your root system. Moving up through the UNDERGROUND WATERS, up through the bedrock, up past the bones of our ancestors, up through the rich topsoil, and right up into the soles of your feet.* -- Wicca Spirituality, "Earth Grounding Meditation," internet posting

An underground river can also be a non-metaphoric ATV spiritual destination.

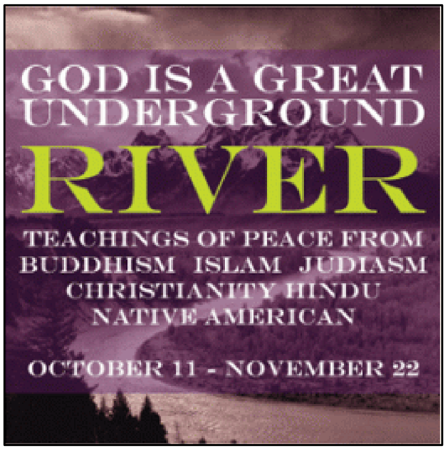
> *Jump on your ATV or Mini-Rhino and drive over back-roads through Playa del Carmen's low shrub-jungle terrain en route to the hidden underground world of the ancient Mayans at the mystical caverns of Chac Tun. You'll be awed by nature's majesty as she surrounds you with spectacular stalactites and stalagmites. Follow your guide into the cavernous depths and experience the power of an ancient Mayan ceremony of purification and renewal performed by a local practitioner of Mayan spirituality. This ritual involves the sacred waters of an UNDERGROUND RIVER as well as fire, earth, music, movement and meditation in the caverns depths.* -- Mayan Destinations, "Sunset ATV and Mayan Ceremony," internet posting

An underground river can provide lore for a new religion.

Fundamental to the image of L. Ron Hubbard as the prophet of Scientology are the tales of his teenage travels. On an unnamed South Pacific island, the fearless lad calmed the natives by exploring a cave that was said to be haunted by showing them that the rumbling sound from within was nothing more sinister than an underground river. Hubbard wouldn't call it spiritual, however; it was simply ascertaining a meaning.

In The Holy Blood and the Holy Grail (1982), Michael Baigent, Richard Leigh and Henry Lincoln speculate that an "UNDERGROUND STREAM" might also have connoted an unacknowledged and thus "subterranean" bloodline of Jesus. As this one's a thriller, the metaphor's not subtle.

Why beat around the bush? God Him/Herself can be an underground river, as per the poster for the 2009 Fetzer-sponsored conference held in Fort Worth, Texas.



Subconscience

These UNDERGROUND RIVERS of sorrow, constantly quaking beneath the surface of everyday life; everybody senses them at one time or another -- Donna Tartt recalling Mississippi writer Willie Morris, internet posting, 2009.

It is the deep undercurrent, I, that is the motive power of life, and it is not perceived by our usual consciousness. Its intense energy goes inward and creates sensitivity, intuition, and the highest mental abilities. The flow of this UNDERGROUND RIVER is the most difficult thing to grasp, and human civilization therefore cannot easily emerge from this dimension either. -- William Gleason, The Spiritual Foundations of Aikido (1995)

As I sit quietly painting, immersed in color and light, just beyond my consciousness violence and desperation run like an UNDERGROUND RIVER. -- Andrea Krupp, artist statement from the exhibition "Places I Know," 2009

He can let go of himself, let himself disappear into that great UNDERGROUND RIVER of the unconscious where one necessarily loses one's self-realization. -- Carl Gustav Jung and James Louis Jarrett, Nietzsche's Zarathustra, Notes of the Seminar Given in 1934-1939 (1988)

Even in the Fabulous Country there is the UNDERGROUND RIVER, which runs deep and silent beneath our consciousness, filling our waking lives with a dark meaning. -- Max Lerner, "Fabulous Country and the Underground River," Saturday Review of Literature, December 5, 1959

Jazz musicologists such as Gunther Schuller have speculated that Charlie Parker's skill at splitting the four beats of a bar into eight could be a reincarnation of subconscious impulses inherited from a mental UNDERGROUND RIVER from Africa. -- Billboard, May 21, 1977

Film lives somewhere in that UNDERGROUND RIVER of the psyche which travels from the domain of sex through the deeps of memory and the dream on out into the possible montages of death. -- Norman Mailer, The Spooky Art, Thoughts on Writing (2004)

Her personal life, her own realization of herself, was almost a subconscious existence; like an UNDERGROUND RIVER that came to the surface only here and there at intervals months apart, and then sank again to flow on under her own fields. -- Willa Cather, O Pioneers! (1913)

Tradition

The sub-consciousness is the governor of the waking brain. Tradition -- which is just man's memory of man -- flows through it like an UNDERGROUND RIVER from which rise the springs of every-day thinking. -- Henry Seidel Canby, Definitions, Essays in Contemporary Criticism (1922)

> *Repressed by the missionaries, the SUBTERRANEAN STREAM of tribal tradition was still operative in controlling the Indians and ready to break forth on the surface with the first release of external pressure.* -- R Shonle, "The Christianizing Process among Preliterate Peoples," Journal of Religion 4, 1924

Unappreciation

> *The editors have been deeply attracted to the vivid movement and activity of his poetry, which seem to flow up from an UNDERGROUND RIVER that lies beneath mere speech, as though written in some pre-verbal language of which all later languages have proved to be a mere translation.* -- Peter Davison, "A Reflection on Poet W.S. Merwin," Atlantic Monthly, August 28, 1997

Union

> *In the pit of the night our bodies merge,*
> *dark clouds passing through each other in lightning,*
> *the joining of RIVERS FAR UNDERGROUND in the stone.*
> *I feel thick but hollow, a polyp floating on currents.* -- Erica Jong, Half-Lives (1973)

Unseen

> *My life is like the SUBTERRANEAN RIVER in the Peak of Derby, visible only where it crosses the celebrated cavern*. -- Walter Scott, Redgauntlet (1824)

Vision

> *Joins the UNDERGROUND RIVER of ecstatic visionaries, what Gary Snyder calls "the Great Subculture," which connects the cave painters with Blake, Cezanne, and Mondrian.* -- Peter Acheson, "Mind Mandala, The Art of James Harrison," The Brooklyn Rail, April 2006

Waste

> *For the first time in our history there is an overwhelming economic pinch, following the Great War and stretching around the world. We have turned our attention in this country, as never before, to the problem of waste -- waste in Governmental expenditures and processes, waste in industry.* -- Frederick M. Davenport, "UNDERGROUND RIVERS of Waste," The Outlook, An Illustrated Weekly Journal of Current Life, January-April 1922

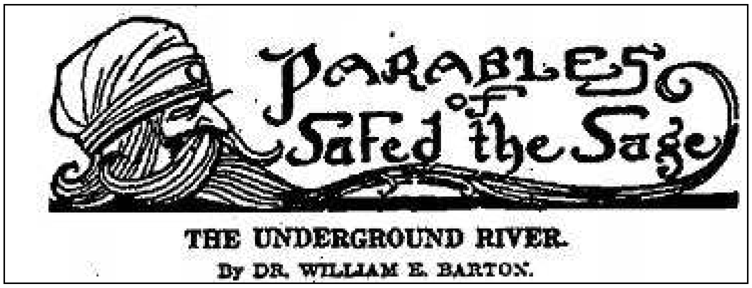
Wisdom

> *There are many wells of faith and knowledge drawing from one UNDERGROUND RIVER of Divine wisdom. The practice of honoring, learning and celebrating the wisdom collected from these wells is Deep Ecumenism.* -- Creation Spirituality Communities, "Twelve Principles of Creation Spirituality," internet posting
>
> *Medieval alchemists referred to these teachings as the UNDERGROUND RIVER, which flowed through time carrying the ancient wisdom.* -- Dennis William Hauck, Sorcerer's Stone, A Beginner's Guide to Alchemy (2004)

What seems most noteworthy regarding "underground rivers" is the spectrum of meanings. In the manner of Alice in Wonderland's Queen of Hearts, "A word means what I want it to mean; nothing more, nothing less."

Apparently, so can a metaphor.

For smothering bombasticy, a metaphoric underground river can flow like the Mississippi. William E. Barton split his writings between treatises on the life of Abraham Lincoln and weighty parables attributed to the wise Safed the Sage. We'll quote one of the latter, published in the Syracuse Journal, October 16, 1901.



Parables of Safed the Sage

THE UNDERGROUND RIVER.

By DR. WILLIAM E. BARTON.

> *I journeyed in the Land of the Big Red Apple, where they raise fruit as delicious as that with which Eve tempted Adam. For Eve knew her business, and the Apple is Some Fruit. And I saw the trees laden with fruit, and the ground beneath them growing green with Alfalfa.*
>
> *And I asked, Whence cometh the water, with which these trees are nourished? For the clouds drop not their rain, neither is there melting snow upon the distant hills.*
>
> *And they showed me a deep well that went down a hundred cubits. And at the bottom I saw an Engine that worked with Electric Power, and rested not day nor night.*
>
> *And the engine lifted the water in a Mighty Stream so strong that when it reached the surface they had to hurl it against a wall, and divide it into smaller streams lest it tear up the very ground. And the water flowed unto Many Orchards, and watered the trees.*
>
> *And the trees brought forth fruit in their season. And there are no years when the crop faileth for lack of water. For there is a Mighty River that floweth under the ground, and its flow is perpetual. And everything doth grow, whithersoever the river cometh.*
>
> *And when I saw these things, I said, Behold there be many men whose lives are Sterile and Barren of good works, who might Grow and Blossom and Bear Fruit.*
>
> *For there floweth under the feet of every man streams of Power; and there are in the life of men Hidden Reservoirs whereof the might Drink and water the ground abundantly.*
>
> *For there is no need that any life should be barren, or that any man should fail to lift up toward heaven the evidences of a life that is useful and good and shineth upon the evil and the good. The sun is in the sky, and there are springs of water in the earth, and no man's life should be unfruitful.*

Few pieces of English literature employ both King James prose and reference to Engines that work with Electric Power. As for the allusion to an underground river, who amongst us denyeth that no man's life should be unfruitful?

We'll end our catalog with a metaphoric prognostication by the New York Times, March 1915.

> *Now, the German and the Englishman are not in the least alike -- except in the sense that neither of them are negroes. They are, in everything good and evil, more unlike than any other two men we can take at random from the great European family. They are opposite from the roots of their history -- nay, of their geography. It is an understatement to call Britain insular. Britain is not only an island, but an island slashed by the sea till it nearly splits into three islands, and even the midlands can almost smell the salt. Germany is a powerful, beautiful, and fertile inland country, which can only find the sea by one or two twisted and narrow paths, as people find a SUBTERRANEAN LAKE. Thus the British Navy is really national because it is natural. It has cohered out of hundreds of accidental adventures of ships and shipmen before Chaucer's time and after it. But the German Navy is an artificial thing, as artificial as a constructed Alp would be in England.*

Made a month before the Lusitania was sunk by a German U-Boat, "As people find a subterranean lake" turned out to be tragically illusionary.

A well-crafted metaphor can, in fact, be quite literal.

In The Dark River (2008) by John Twelve Hawks, all citizens are pawns in a game where only the bad side knows the rules (or, for that matter, that there's even a game on). The First Realm, hell, is replete with its own River Styx, which Maya, who's on the good side, must negotiate.

> *She knelt on the floor and lowered her head beneath the water. Lying flat, she moved toward the opening in the wall. Maya could hear her own breath, the bubbles coming out of the regulator, and a scraping sound from the edge of her pony tank and she dragged it along the limestone floor.*
>
> *When she reached the opening, she extended her arm and pointed the flashlight into the darkness. Over the years, the flowing water had cut an underground tunnel through the rubble of the past. The walls of the tunnel were an aggregate of stones, Roman brick, and chunks of white marble. It looked fragile, as if everything would crumble, but the real danger was created by the present era. In order to support the collapsing foundations of the building, someone had driven steel rods deep into the ground. The tips of the rods jutted into the tunnel like the tips of rusty sword blades.*

The plot is much the same as most of the genre -- lots of close calls, etc., future film rights in the writer's mind -- but the underground river flowing through past eras, endangered by the present "like the tips of rusty sword blades," evokes the imagination of the reader.

To harvest similes, we need only peruse liberal arts journals. There are too many.

Herbert Shore	Remembering Eduardo, Reflections on the Life and Legacy of Eduardo Mondlane	Africa Today Winter-Spring 1992	*The resurgence of interest in Mondlane among Mozambicans is LIKE AN UNDERGROUND RIVER rising to the surface.*
Walton Hamilton	English Social History, A Survey of Six Centuries, by G.M. Trevelyan	American Economic Review March 1944	*The current scene holds all the ages; the stream of causal events, unfixed by positive dates, "flows on LIKE AN UNDERGROUND RIVER"; a culture in all its confused contrariness is adamant to the keen tools of logical analysis..*
Jay Winter	Film and the Matrix of Memory	American Historical Review June 2001	*Bodnar takes issue with work on traumatic memory, understood AS AN UNDERGROUND RIVER of recollection, likely to erupt unbidden when triggered by some external stimulus*
Judith Adler	Travel as Performed Art	American Journal of Sociology May 1989	*LIKE AN UNDERGROUND STREAM, they gather force before they are noticed, disappear only to resurface again in modified guise, or, taking hidden turns, give an appearance of novelty while drawing on enduring sources.*
Robert K. Martin	Hercules in Knickerbockers: Class, Gender, and Sexuality in The Landlord at Lion's Head	American Literary Realism April 1988	*That dream of a boyish, egalitarian love ran LIKE AN UNDERGROUND STREAM throughout the art of the nineteenth century, emerging in the works of Whitman or Eakins or even Twain, and bubbling up one last time in E.M. Forster.*

Emory Elliot	The Dove and Serpent, The Clergy in the American Revolution	American Quarterly Summer 1979	*What Jefferson and his fellow intellectuals understood about their countrymen was that religious feeling flowed LIKE AN UNDERGROUND RIVER through the colonies from New England to Georgia and might be brought to the surface with the appropriate codes and symbols.*
Wilma Shore	The Man in the Subway	Antioch Review July 1962	*The four tracks run between the platforms LIKE AN UNDERGROUND STREAM*
Bob Holman and Richard Tuttle	Richard Tuttle	BOMB Oct. 1992	*When his work was over, it went underground -- moving along in history LIKE AN UNDERGROUND RIVER*
Astrid Ivask	Kdjdmgdjejs un Muziba, by Maris Caklais	Books Abroad April 1968	*This commitment expresses itself in tenderness as well as irony, but most often in a streak of compassion that feeds his poetry LIKE AN UNDERGROUND STREAM.*
Gavin Mackenzie	Labour and Monopoly Capital, The Degradation of Work in the Twentieth Century, by Harry Braverman	British Journal of Sociology June 1977	*But beneath this apparent habituation the hostility of workers... continues AS A SUBTERRANEAN STREAM that makes its way to the surface when employment conditions permit or when capitalist drive... oversteps the bounds of physical and mental capacity.*
E.S. Drower	Mandaean Polemic	Bulletin of the School of Oriental and African Studies Jan. 1962	*Such a persecution would explain the violent abhorrence for orthodox Judaism which runs LIKE AN UNDERGROUND STREAM throughout Nasoraean (Mandaean) literature.*
Keith Roberts	Painting in the Maceratese	Burlington Magazine Nov. 1971	*The strong religious strain that runs, LIKE A SUBTERRANEAN STREAM, beneath the desolate, burning landscape in which his imagination often so chose to linger.*
Gordon K. Lewis	On the Character and Achievement of Sir Winston Churchill	Canadian Journal of Economics and Political Science May 1957	*The slow and patient accumulation of knowledge which fertilizes a whole field of thought LIKE AN UNDERGROUND STREAM means relatively little to him except as it contributes to the great moment when the supreme gesture can be made.*
Colin S. Campbell and J. Rick Ponting	The Evolution of Casino Gambling in Alberta	Canadian Public Policy June 1984	*It runs LIKE A SUBTERRANEAN STREAM through numerous case studies of policy formulation.*

Herbert Shore	To Side with the Light: Conscience and Power in the Drama of Barrie Stavis	Cardozo Studies in Law and Literature Oct. 1990	*And in a scene toward the end of Lamp at Midnight, Francesco Barberini, the cardinal-nephew of the Pope, warns the latter that "Truth, LIKE AN UNDERGROUND STREAM, can be stopped up, but someday will rise to the surface."*
Elizabeth Ward Loughran	The Role of Catholic Culture in Bolivia	Catholic Historical Review April 1940	*LIKE AN UNDERGROUND STREAM this culture flowed unseen under the barren and scanty state-controlled education of the nineteenth century.*
Carol Zaleski	Whatever Happens	Christian Century Nov. 18, 2008	*Precariousness that runs below our activities LIKE AN UNDERGROUND STREAM.*
Brendan McNamee	The Flowering Cross: Suffering, Reality, and the Christ Motif in Francis Stuart's The Pillar of Cloud and Redemption	Christianity and Literature Autumn 2003	*The sense of another reality runs LIKE A SUBTERRANEAN STREAM through Redemption.*
Thos. A. Brady	Early Ionian Historians, by Lionel Pearson	Classical Journal Feb. 1943	*We should see this broad stream of non-Athenian tradition, submerged LIKE AN UNDERGROUND RIVER during the fifth and fourth centuries, come into view again as the central current in the culture of the Hellenistic age.*
Michael Atkinson	Sherlock Holmes and The Red-Headed League, A Symbolic Paradigm for the Teaching of Plot	College Literature April 1980	*Suddenly we have been given access to Holmes' thoughts, which have been running silently beneath the events all along, LIKE AN UNDERGROUND STREAM ready to burst up in a spring?*
Robert Lipsyte	Damon Runyon	Columbia Journalism Review Nov. 1991	[The] *story about his second wife, Patrice, which runs through the book LIKE AN UNDERGROUND STREAM.*
Midge Decter	Homosexuality and the Schools	Commentary March 1993	*Devoted to the theme that has run LIKE AN UNDERGROUND STREAM through the whole curriculum.*
Grigore Nandris	The Historical Dracula, The Theme of His Legend in the Western and in the Eastern Literatures of Europe	Comparative Literature Studies Jan. 1966	*A turbid, undefined undertone runs LIKE A SUBTERRANEAN STREAM through Bram Stoker's Dracula.*
Judith Ryan	The Intertextual Maze, Rilke's Der Turm and His Relation to Aestheticism	Comparative Literature Studies Jan. 1993	*Rilke's image of the tower stair AS AN UNDERGROUND RIVER has its origin in an important episode in Rodenbach's Le Carilloneur*

Michael Bright	"Most Capital Enemies of the Muses: War, Art, and Kubla Khan"	Comparative Literature Studies Dec. 1984	*The first of these ideas is that art is LIKE A SUBTERRANEAN RIVER, emerging spontaneously and unexpectedly at certain times and places, flowing for a spell, and then, as suddenly as it had appeared, submerging to hidden caverns.*
Donald Bruce	The Age of Rembrandt at the Queen's Gallery	Contemporary Review Aug. 2005	*The picture seeped up into Rembrandt's imagination LIKE AN UNDERGROUND STREAM from his assiduous reading of the gospel of St John.*
Mary Doyle Springer	Upon Rereading Fiction and the Shape of Belief	Critical Inquiry Dec. 1979	*Some of these ideas, such as the stiffly worded but unparaphrasable definitions of the types of fiction, continue to reverberate LIKE AN UNDERGROUND STREAM, echoed by several "generations" of Sheldon Sacks' students.*
Helga Duncan	Headdie Ryots as Reformations, Marlowe's Libertine Poetics	Early Modern Literary Studies Sept. 2006	*A "haeresis perennis, a perennial heresy" whose tradition is LIKE AN UNDERGROUND RIVER, which we can trace back and back, perhaps to the time of Christ.*
Herb Shore	The Humanist Alternative, by Barrie Stavis	Educational Theatre Journal Dec. 1973	*"Truth," says Barrie Stavis, "is LIKE AN UNDERGROUND STREAM. It can be stopped up, but some day it will rise to the surface."*
Kristin Bryant	Oates's I Lock My Door Upon Myself	Explicator Fall 1993	*The impersonal life that flowed through her LIKE AN UNDERGROUND STREAM.*
Brent Nelson	Cain-Leviathan Typology in Gollum and Grendel	Extrapolation Winter 2008	*He found a little cave out of which the dark stream ran [LIKE GRENDEL'S SUBTERRANEAN RIVER]; and he wormed his way like a maggot into the heart of the hills.*
James S. Duncan	America, by Jean Baudrillard	Geographical Review Jan. 1990	*Yet an older European discourse runs, perhaps undetected by Baudrillard himself, LIKE A SUBTERRANEAN RIVER through this work.*
Francis B. Sayre	Criminal Conspiracy	Harvard Law Review Feb. 1922	*Thus, LIKE AN UNDERGROUND STREAM that ever keeps coming to the surface, the doctrine, constantly reiterated in the loose dicta of courts and the statements of text-writers, has kept appearing and reappearing ever since Hawkins' time,*

Declan Kiberd	Fallen Nobility, The World of John McGahern	Irish University Review Spring-Summer 2005	*The days were quiet. They did not feel particularly quiet or happy but through them ran the sense, LIKE AN UNDERGROUND RIVER, that there would come a time when these days would be looked back on as happiness, all that life could give of contentment and peace.*
Carlo Levi, R. and D. Catani	Structure and Style as Fundamental Expression, The Works of Carlo Levi and Their Poetic Ideology	Italica July 1901	*In the civilized world of reason and history, however, this poetic moment is, he asserts, elsewhere, like the memory of a previous existence, LIKE AN UNDERGROUND RIVER that surfaces unexpectedly.*
Corina Martin-Jordache	Modernity, Urban Semiology and the Beckettian Cityscape	Journal of European Studies Dec. 2002	*LIKE AN UNDERGROUND RIVER rippling the stylized surface of the written page.*
Jean H. Delaney	Imagining "El Ser Argentino," Cultural Nationalism and Romantic Concepts of Nationhood in Early Twentieth-Century Argentina	Journal of Latin American Studies Aug. 2002	*Rojas believed what really counted were the hidden processes shaping the nation's character and destiny, such as the blood of Argentina's indigenous peoples that he believed flowed LIKE A SUBTERRANEAN RIVER In the depths of the Argentine race.*
Daniel R. Schwarz	The Narrative of Paul de Man, Texts, Issues, Significance	Journal of Narrative Technique April 1990	*Truth, LIKE AN UNDERGROUND STREAM, can be stopped up, but someday will rise to the surface*
Winston L. King	Negation as a Religious Category	Journal of Religion April 1957	*There runs through Buddhism, LIKE AN UNDERGROUND RIVER, the positive, even luminous, religious experience.*
Muhsin Mahdi	Al-Fārābī's Imperfect State	Journal of the American Oriental Society Oct. 1990	*Yet there is nothing surprising about this approach, once the simile of a text traveling LIKE AN UNDERGROUND RIVER takes possession of the researcher's mind.*
Edwin A. Cranston	Aspects of the Tale of Genji	Journal of the Association of Teachers of Japanese May 1976	*Two illicit liaisons and their consequences provide much of the continuity which runs LIKE A SUBTERRANEAN STREAM from the beginning of the novel to its end.*
Gerhard Masur	Wilhelm Dilthey and the History of Ideas	Journal of the History of Ideas Jan. 1952	*Here Dilthey shows how Hegel's ideas had grown out of poetical passion and suffering equal to that which moves Holderin's lyrics, and how this origin, LIKE A SUBTERRANEAN RIVER, still pulses in the fully developed system.*

Carolyn Kizer	A Month in Summer	Kenyon Review July 1962	*And love -- doesn't it endure somewhere peacefully, LIKE AN UNDERGROUND RIVER, beneath all this dust and meaningless commotion on the surface?*
Thomas A. Tweed	At Home on the Earth, edited by David Landis Barnhill	MELUS April 2000	*A concern to live responsibly in nature runs through this evocative anthology LIKE A SUBTERRANEAN STREAM.*
Lawrence Dugan	Orwell and Catholicism	Modern Age Summer 2006	*Ruminating in print over how a writer's social and political beliefs seem to move beneath what he writes LIKE AN UNDERGROUND STREAM.*
Michael Caesar	Linguae stile di Giacom Loeopardi Atti dell'VIII Convegnion ternazionadlei studil eopardiani	Modern Language Review July 1996	*Leopardi's stated desire to create "a modern national language," and at the same time to reach back to the old, "illustrious," language separated from the present by the chasm that the seventeenth century opened in the nation's literature, runs LIKE AN UNDERGROUND STREAM beneath many of the contributions to the 1991 conference.*
Ruth Morse	Medieval Biography, History as a Branch of Literature	Modern Language Review April 1985	*I wish to insist upon the importance of Suetonius, whose influence flows here AS AN UNDERGROUND STREAM, there as a clear river, and everywhere nourishes medieval attitudes to the writing of lives either directly or through the medium of his imitators.*
Theresa M. Krier	Worldmaking Spenser, Explorations in the Early Modern Age, edited by Patrick Cheney and Lauren Silberman	Modern Philology Nov. 2001	*A "poet's poet" whose influence moves through later writing LIKE AN UNDERGROUND RIVER, less easily mapped than Shakespeare's or Milton's*
Francis Mathy	Modern Japanese Stories, by Ivan Morris	Monumenta Nipponica 1963	*How could I imagine a love LIKE A SUBTERRANEAN STREAM, with no sunshine and no one to know where the water comes from and goes.*
Gedaliahu Stroumsa	The Gnostic Temptation	Numen December 1980	*Such a more or less avowed inclination toward Gnostic views or attitudes can admittedly be detected AS AN UNDERGROUND STREAM throughout western intellectual history.*
Craig Wollner	The Portland Red Guide, Sites & Stories of Our Radical Past	Oregon Historical Quarterly Spring 2008	*A current of radical thought and action running through its past LIKE AN UNDERGROUND RIVER -- swift, seldom seen, but occasionally bubbling to the surface.*

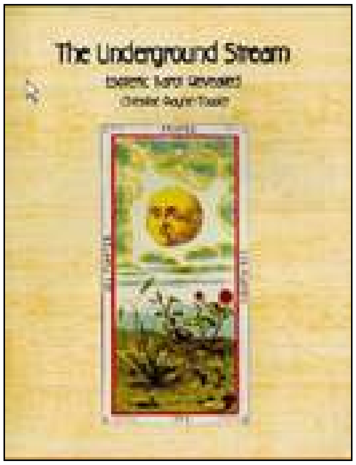
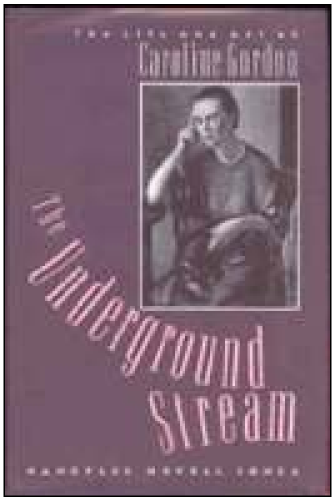
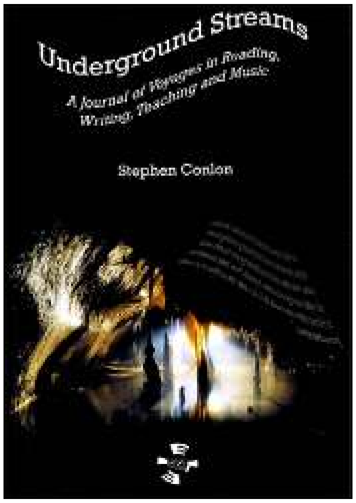
Alexander Saxton	In Dubious Battle, Looking Backward	Pacific Historical Review May 2004	*Sometimes that current flowed powerfully on the surface, sometimes (as in our own era) deep-delved LIKE AN UNDERGROUND STREAM.*
Andrew Rolle	Exploring an Explorer, Psychohistory and John Charles Frémont	Pacific Historical Review May 1982	*Although his childhood frustrations did sink out of sight (LIKE AN UNDERGROUND STREAM below the prairies he was to traverse), later they reappeared in different forms.*
James Seaton	On Politics and Literature, The Case of O Pioneers	Perspectives on Political Science Summer 1999	*Her personal life, her own realization of herself, was almost a subconscious existence; LIKE AN UNDERGROUND RIVER that came to the surface only here and there, at intervals months apart, and then sank again to flow on under her own fields.*
Charles Hampden-Turner	Charting the Dilemmas of Hanover Insurance	Planning Jan. 1992	*The first says that people want to grow and to learn, and that this motive, LIKE AN UNDERGROUND STREAM, is of immense power and significance in human affairs.*
Robert C. Elliott	Swift's Tale of a Tub, An Essay in Problems of Structure	PMLA June 1951	*But beneath the level of subject matter there is a basic theme running LIKE AN UNDERGROUND STREAM which sustains a variety of forms of life above it.*
Fred Dallmayr	Heidegger and Freud	Political Psychology June 1993	*The child's desire-its endless quest for a lost paradise must be tunneled LIKE AN UNDERGROUND RIVER through the subterranean passageways of the symbolic order.*
Emilie L. Bergmann	De Officio Martiti, Introduction, Critical Edition, Translation and Notes	Renaissance Quarterly Winter 2007	*Carelessness or treachery, emerging LIKE AN UNDERGROUND RIVER springing forth from the surface of a familiar landscape.*
J.B. Leishman	Donne's Poetry, Essays in Literary Analysis, by Clay Hunt	Review of English Studies July 1956	*This admirable, if ambitious, intention too often seems to disappear LIKE AN UNDERGROUND STREAM.*
Robert D. Finley	Dao De Jing, A Brief Illustrated Philosophy of Translation	ReVision Summer 2003	*Wonderfully potent image that runs through the Dao De Jing LIKE AN UNDERGROUND STREAM surfacing now and then, may come to our aid.*
Anon.	Editorial Notes	School Review Oct. 1906	*It may lead for some time an intermittent and fugitive existence, flowing LIKE A SUBTERRANEAN STREAM entirely below the surface of several issues of the Review, and reappearing perhaps at irregular intervals.*

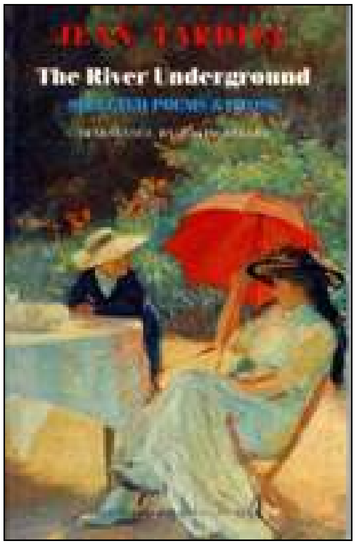
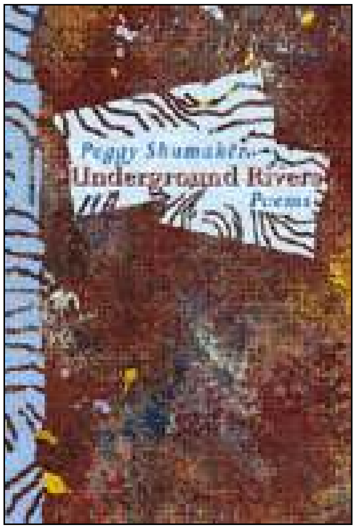
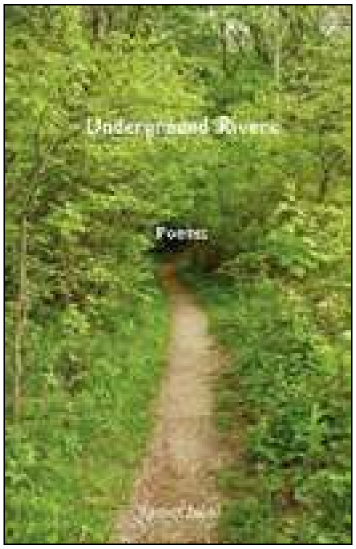
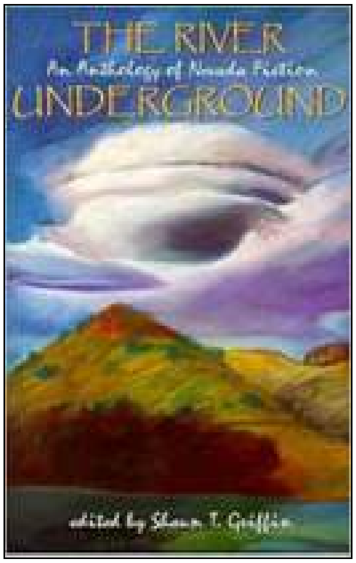
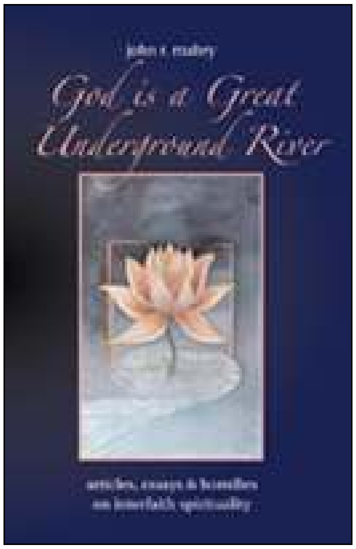
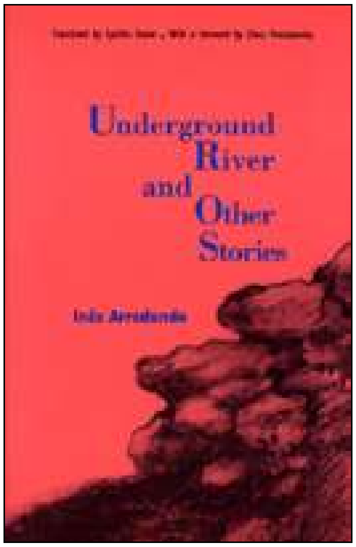
George J. Dudycha	What Is Evolution?	Scientific Monthly Oct. 1929	*Again, he thinks of the process of development AS A SUBTERRANEAN STREAM which is forcing its way through rock and sand, and whose course is being determined by that which it encounters as well as by the force which it maintains.*
Kathleen Raine	Traditional Symbolism in "Kubla Khan	Sewanee Review Oct. 1964	*LIKE AN UNDERGROUND RIVER that from time to time sends up springs and fountains, Platonism emerges in different centuries and different countries.*
Judith Robey	Gender and the Autobiographical Project in Nadezhda Mandelstam's Hope against Hope and Hope Abandoned	Slavonic and East European Journal Summer 1998	*Sarah Pratt also sees the autobiographical element in Nadezhda Mandelstam's memoir as something hidden, noting that it "flows LIKE A SUBTERRANEAN STREAM beneath the surface of the prose, nourishing the visible growth above."*
Kathleen Parthe	Invisible Allies, by Aleksandr Solzhenitsyn	Slavonic and East European Journal Spring 1998	*And in each case an autobiographical element flows LIKE A SUBTERRANEAN STREAM beneath the surface of the prose.*
Walter Comins-Richmond	Autobiography Studies, edited by Marina Balina	Slavonic and East European Journal April 1998	*And in each case an autobiographical element flows LIKE A SUBTERRANEAN STREAM beneath the surface of the prose.*
Želimir B. Juričić	Andrić's Visions of Women in Ex Ponto	Slavonic and East European Journal Summer 1979	*Man has no control over forces which love sets in motion deep within him, "the forces which keep rushing to the surface LIKE AN UNDERGROUND STREAM, unbidden and unsuspected, welling up at different points and in different strengths."*
Arnold McMillin	Dostoyevskay and the Process of Literary Creation by Jacques Catteau	Slavonic and East European Review Oct. 1990	*The "migrant images" of which the most persistent is the "Life of a Great Sinner," which runs LIKE AN UNDERGROUND STREAM beneath all the mature novels, and which has almost certainly never before been traced with such clarity and insight.*
Howard M. Bahr and Kathleen S. Bahr	Families and Self-Sacrifice, Alternative Models and Meanings for Family Theory	Social Forces June 2001	*The wisdom of ordinary people and "a legacy of personal virtue that runs LIKE AN UNDERGROUND STREAM beneath the great violent expanse of world history."*

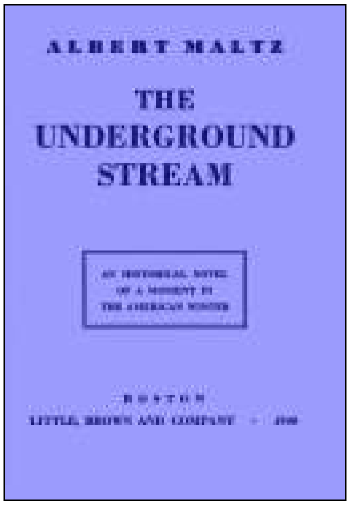
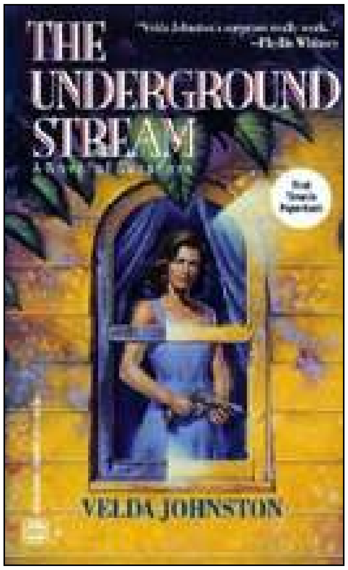
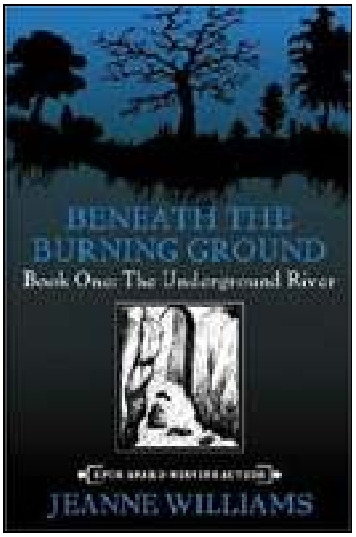
John R. Reed	Inherited Characteristics, Romantic to Victorian Will	Studies in Romanticism July 1978	*Man's nature is fragmented and his "genuine self" buried, following "his being's law" in secret LIKE A SUBTERRANEAN RIVER, while the superficial selves might "seem to be /Eddying at large in blind uncertainty, /Though driving on with it eternally"*
Geoffrey Sanborn	Melville's Anatomies	Studies in the Novel Winter 1999	*To locate those politics beneath the surface of the text, as though all such meanings run LIKE AN UNDERGROUND RIVER in remote allegorical depths.*
Alexander Laszlo, Kathia Castro Laszlo and Halim Dunsky	Redefining Success, Designing Systemic Sustainable Strategies	Systems Research and Behavioral Science Jan. 2010	*The design journey is best conceived as an ongoing conversation, LIKE AN UNDERGROUND RIVER along which wellsprings of opportunity emerge.*
Sabrina Artel	At Breakneck Speed, Performing with Dar A Luz	TDR Winter 1995	*This work with Dar A Luz is LIKE AN UNDERGROUND STREAM rushing into my body, crossing borders and entering.*
Eugene M. Longen	Dickey's Deliverance, Sex and the Great Outdoors	Southern Literary Journal Spring 1977	*When Ed later reflects on all that has happened, he recognizes that dark mysterious part of himself, LIKE AN UNDERGROUND RIVER of great depth and power.*
Greil Marcus	The Lost Waltz	Threepenny Review Oct. 2004.	*Far beneath the quick and wary steps in Robertson's solo is something LIKE AN UNDERGROUND STREAM -- or whatever image Garth Hudson's organ calls up*
Rudolph Ballentine	Radical Healing and the Rebirth of Science	Townsend Letter for Doctors and Patients Feb. 2001	*The enduring existence of this consciousness as it flows LIKE A SUBTERRANEAN RIVER through our inner lives.*
Angela Yiu	From Utopia to Empire, Atarashikimura and a Personal View of the Greater East Asia War (1942)	Utopian Studies Spring 2008	*"A new Asia (shin no Ajia)" and "peace" (heiwa) flow abundantly and steadily LIKE A SUBTERRANEAN RIVER that connects and nourishes the conception of Atarashikimura.*
Doctress Neutopia	Wise Womyn Ways, Gaia Rhythms	Utopian Studies Spring 1998	*LIKE AN UNDERGROUND STREAM, the wisdom traditions of womyn underlie all cultural traditions.*

Wendell S. Johnson	Arnold's Main Stream	Victorian Poetry July 1967	*Here man is reconciled with himself, either the Buried Self tending LIKE AN UNDERGROUND RIVER to flow into a tranquil sea or the Best Self of the regenerate, the child of a Second Birth.*
Kirsti Simonsuuri	Muistinavaruus, Kirjoituksia, Puheenvuoroja Vuosilta 1959-1999	World Literature Today Winter 2001	*LIKE A SUBTERRANEAN STREAM gradually emerging, it makes obvious that her poetic and aphoristic vision.*
Henry W. Ehrmann	Pressures in a Divided France	World Politics Oct. 1958	*For Fauvet, the Bonapartist and nationalist tradition, LIKE AN UNDERGROUND RIVER, disappears in Gaullism and reappears in Poujadism.*
Jean-Christophe Bailly and Benjamin Elwood	A River With No Novel	Yale French Studies 1992	*On the one hand, this flow is LIKE AN UNDERGROUND RIVER, whose resurgences guide the observable text by replenishing it.*
Marcello Sorce Keller	Italian Treasury, Puglia, The Salento	Yearbook for Traditional Music Jan. 2003	*A large body of traditional music (somewhat LIKE AN UNDERGROUND STREAM), which, unnoticed by music historians, had continued to exist in almost complete separation from the flourishing art-music tradition of the Peninsula.*

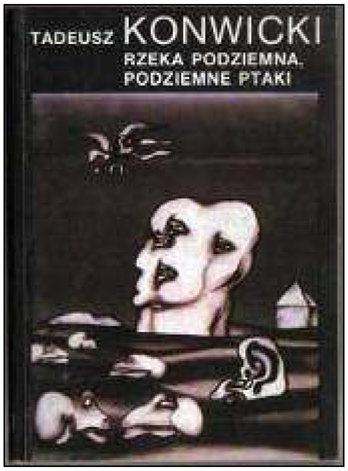
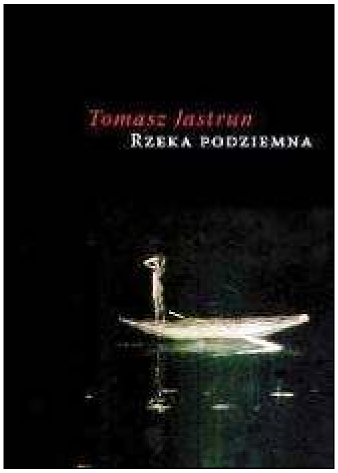
As the above table makes us appreciate the visual, here are covers from a few metaphorically-titled books.

 The Underground Stream Esoteric Tarot Revealed Christine Payne-Towler Christine Payne-Towler, The Underground Stream, Esoteric Tarot Revealed (1999)	 THE LIFE AND ART OF Caroline Gordon The Underground Stream NANCYLEE NOVELL JONZA Nancylee N. Jonza, The Underground Stream, The Life and Art of Caroline Gordon (1995)	 Underground Streams A Journal of Voyages in Reading, Writing, Teaching and Music Stephen Conlon Stephen Conlon, Underground Streams, A Journal of Voyages in Reading, Writing, Teaching and Music (2003)

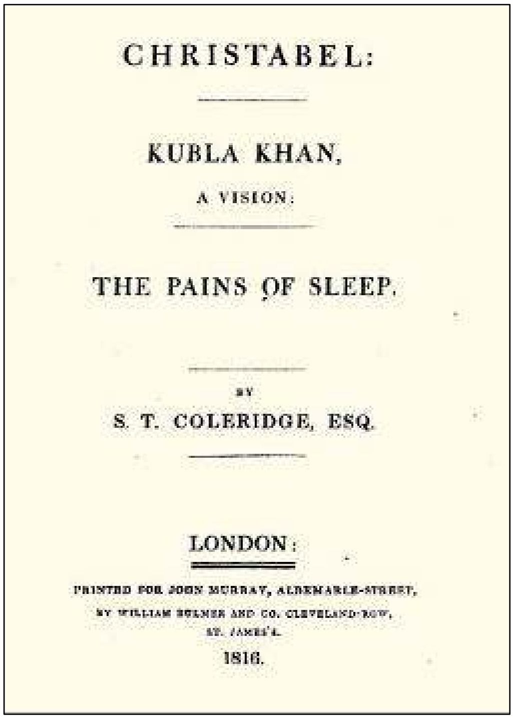
 JEAN TARDIEU The River Underground SELECTED POEMS & PROSE Jean Tardieu, The River Underground, Selected Poems & Prose (1991)	 Peggy Shumaker Underground Rivers Poems Peggy Shumaker, Underground Rivers (2002)	 Underground Rivers Poems James Neal, Underground Rivers, Poems (2008)
 THE RIVER An Anthology of Nevada Fiction UNDERGROUND edited by Shaun T. Griffin Shaun T. Griffin, The River Underground, An Anthology of Nevada Fiction (2001)	 john r. mabry God is a Great Underground River articles, essays & homilies on interfaith spirituality John R. Mabry, God as a Great Underground River (2006)	 Underground River and Other Stories Inés Arredondo Inés Arredondo, Underground River and Other Stories (1996)

 ALBERT MALTZ THE UNDERGROUND STREAM BOSTON LITTLE, BROWN AND COMPANY Albert Maltz (one of the blacklisted "Hollywood 10"), The Underground Stream (1940), in the library of Ernest Hemmingway	 THE UNDERGROUND STREAM VELDA JOHNSTON Velda Johnston, The Underground Stream (1991)	 BENEATH THE BURNING GROUND Book One: The Underground River JEANNE WILLIAMS Jeanne Williams, Underground River, Beneath the Burning Ground (2004)

And lest we be exclusively Anglocentric, here we have two Polish works, Underground River, Underground Birds about the immigrant experience in New York City and Underground River by a veteran of Solidarity. The third work, a novel about the Gulag, is in Azerbaijani.

 TADEUSZ KONWICKI RZEKA PODZIEMNA, PODZIEMNE PTAKI Tadeusz Konwicki, Rzeka Podziemna, Podziemne Ptaki ("Underground River, Underground Birds," 1985)	 Tomasz Jastrun RZEKA PODZIEMNA Tomasz Jastrun, Rzeka Podziemna ("Underground River," 2005)	МЕҺДИ ҺҮСЕЈН ЈЕРАЛТЫ ЧАЈЛАР ДӘНИЗӘ АХЫР... Mehdi Husein, Yeralty Chaylar Daniza Akhir ("Underground Rivers Flow into the Sea," 1966)

CHAPTER 30
DOWN TO A SUNLESS SEA



CHRISTABEL:

KUBLA KHAN,
A VISION:

THE PAINS OF SLEEP.

BY
S. T. COLERIDGE, ESQ.

LONDON:
PRINTED FOR JOHN MURRAY, ALBEMARLE-STREET,
BY WILLIAM BULMER AND CO. CLEVELAND-ROW,
ST. JAMES'S.
1816.

Poet Samuel Coleridge (1772-1834), a founder of the English Romantic Movement, is known for both “The Rime of the Ancient Mariner” and his 1816 "Kubla Khan, or A Vision in a Dream," the first stanzas being,

> *In Xanadu did Kubla Khan*
> *A stately pleasure-dome decree:*
> *Where Alph, the sacred river, ran*
> *Through caverns measureless to man*
> *Down to a sunless sea.*
>
> *And from this chasm, with ceaseless turmoil seething,*
> *As if this earth in fast thick pants were breathing,*
> *A mighty fountain momently was forced*
> *Amid whose swift half-intermitted burst*
>
> *Huge fragments vaulted like rebounding hail,*
> *Or chaffy grain beneath the thresher's flail*
> *And 'mid these dancing rocks at once and ever*
> *It flung up momently the sacred river.*
>
> *Five miles meandering with a mazy motion*
> *Through wood and dale the sacred river ran,*
> *Then reached the caverns measureless to man,*
> *And sank in tumult to a lifeless ocean*

As with several authors of subterranean fiction -- Poe, Carroll and Doyle, Chapter 16, come to mind -- drug-induced hallucinations assisted Coleridge's "vision in a dream." But perhaps it wasn't entirely a dream. Coleridge's reading suggests sources for his acquaintance with underground rivers.

Scientific Influences

From his student days at Cambridge, Coleridge was acquainted with the emerging science, as James McKusick documents in "'Kubla Khan' and the Theory of the Earth," Samuel Taylor Coleridge and the Sciences of Life (2001), Nicholas Roe, Ed. From Roe's introduction,

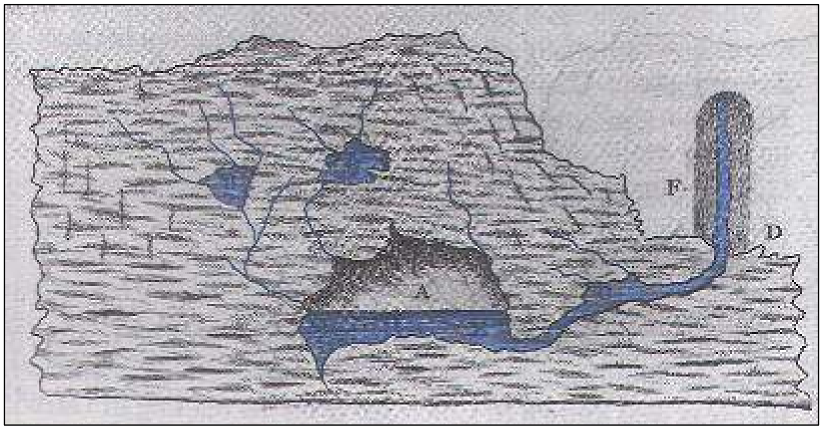
> *James McKusick in "'Kubla Khan' and the Theory of the Earth" examines the development of Coleridge's lyric poetry within the historical and intellectual contexts of geological theory... At the center of McKusick's chapter are John Whitehurst and James Hutton, advocates of rival geologies. Whitehurst was a Neptunian, holding that water had shaped the earth, while Hutton as a Plutonist believed that fire was the formative agent... McKusick shows how "Kubla Khan" incorporates the most up-to-date elements of geoscience. The poem reconciles the Neptunian and Plutonic theories in stanzas which might be seen as "a series of geological fragments" -- fragments of the epic on "universal science" in which "cosmology, geology, biology, hydrography, and agriculture" are interrelated.*

Let us look at several volumes with which Coleridge would likely have been familiar.

In a note to The Botanic Garden (1791, the frontispiece to the right), English naturalist Erasmus Darwin describes a "romantic common" where two rivers disappear into the earth:

> *Near the village of Wetton, a mile or two above Dove-Dale, near Ashburn, in Derbyshire, there is a spacious cavern about the middle of the ascent of the mountain, which still retains the name of Thor's House; below it is an extensive and romantic common, where the rivers Hamps and Manifold sink into the earth, and rise again in Ham gardens, the seat of John Port, Esq. about three miles below.*

The figure "Caverns and Mighty Fountains" from John Whitehurst's An Inquiry into the Original State and Formation of the Earth; Deduced from Facts and the Laws of Nature (1786) is to the right. Whitehurst describes the same subterranean river in terms foreshadowing images in "Kubla Khan."



> *The mountains of Derbyshire, and the moorlands of Staffordshire appear to be so many heaps of ruins... They are broken, dislocated, and thrown into every possible direction, and their interior parts are no less rude and romantic; for they universally abound with subterraneous caverns; and, in short, with every possible mark of violence. The caverns near Buxton and Castleton, and the subterraneous rivers, the Manifold and the Hamps, are familiar instances of the present state and condition of those parts of the globe. The former river, after a passage of four or five miles from the north, and the latter about the same distance from the west both emerge at the foot of the same cliff, in the garden of John Port, Esq. of Ham, about the distance of twenty yards from each other.*

Coleridge would have likely have toured the emergence during a visit to Derby in August 1796.

We can, in fact, tour the site today. During the dry months, the River Hamps flows southward from the moorlands of Derbyshire until it disappears in limestone terrain, reappearing six kilometers downstream at Ilam Park. The River Manifold disappears in the west and upwells at nearly the same location.

The Manifold upwelling

Anthony Harding's review of McKusick's essay the Coleridge Bulletin (21), Spring 2003, however, finds such scientific basis of Coleridge *to* be "rather uneven."

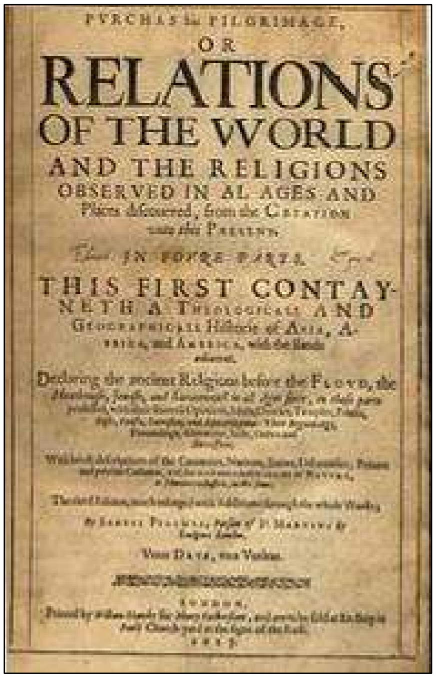
> *The attempt to read "Kubla Khan" as a compendium of geological speculation is, well, speculative. It is certainly true that Coleridge hoped to write "an epic poem that would integrate the lore of 'universal science' into a coherent narrative form," but to conclude that in "Kubla Khan," Coleridge was starting that poem -- "a scientific epic in the genre of Darwin's Botanic Garden" -- is to go beyond what the evidence will support. To take images and terms that were also used by geologists -- river, sea, cavern, hill, chasm, and so on -- as proof that this is a "scientific epic" is persuasive only so long as we ignore evidence that Coleridge was drawing upon a huge range of other sources: the Bible, travel literature* [including an account of Florida's sinkholes [Chapter 40]*, archaeology, mythography, ancient history, ethnography, and so on.*
>
> *McKusick seems determined to hunt for any connection, no matter how flimsy, that might link the poem with geology: so, he makes much of the term "fragment" (used in the 1816 running title), observing pedantically that this term "had a distinct geological sense,", and he connects "chasm" with the story of the Fall via John Whitehurst, a geologist cited in the notes to The Botanic Garden, since Whitehurst "asserted that the... Edenic state of human society was replaced by a fallen state" resulting from a flood.*

Coleridge was versed, for example, in the divine framework of Thomas Burnet's Telluris Theoria Sacra (1694, Chapter 13, Hydrotheology/Theohydrology). While Coleridge may have intended a poetic nod to both 19th century Neptunian and Plutonian geology, his stream of thought remains significantly metaphysical.

Coleridge himself attributes a portion of "Kubla Khan" to Purchas, his Pilgrimage; or, Relations of the World and the Religions observed in all Ages (1613) in which Samuel Purchas recalled the 13-th century Mongolian ruler Kublai, whose palatial estate in Shangdu (Xanadu) was legendary in splendor.

> *In Xanada did Cublai Can build a stately Pallace, encompassing sixteene miles of plaine ground with a wall, wherein are fertile Meddows, pleasant Springs, delightful Streames, and all sorts of beasts of chase and game.*

Xanadu was much later to become the name of Charles Foster Kane's fictional estate in Orson Wells' "Citizen Kane'" (1940). As would have been the case for the Chinese Xanadu, the film's surrealistic grounds "on the deserts of the Gulf coast" could likely sit upon karst terrain (Chapter 39, Karstology), and thus above water-filled caverns.


PVRCHAS his PILGRIMAGE,
OR
RELATIONS
OF THE WORLD
AND THE RELIGIONS
OBSERVED IN AL AGES AND
Places discovered, from the CREATION
unto this PRESENT.
IN FOVRE PARTS.
THIS FIRST CONTAY-
NETH A THEOLOGICALL AND
GEOGRAPHICALL Historie of ASIA, A-
FRICA, and AMERICA, with the Ilands
adiacent.

Unlike Purchas before him, however, or Wells after, Coleridge follows the river into the earth.

Into the Earth

Coleridge describes the Alph in four geological manners.

> As "momently" (i.e. in an instant) flinging itself upward, tossing rocks about, violent.
> As meandering in "mazy motion" through Xanadu's woods and dales,
> As descending into "caverns measureless to man," and of special interest to us,
> As tributary to a "sunless sea."

As each process has geologic possibility, we're tempted to sketch a hydrologic cross-section, the subterranean portion downward from the cavern, but such a figure produces a fluvial morphology in disaccord with that of any waterway we know. Within a brief five-miles, there is both the fearful upwelling and the idyllic riparian countryside. Streamflow incised in deep canyons doesn't meander; it tumbles. How can a sea be sunless?

Let us begin with the river's name.

> "Alph, the sacred river" likely alludes to the Arcadian River Alpheus of Chapter 28, Et In Arcadia Ego.
>
> "Alph" could be the Greek letter, alpha, the original place.
>
> According to Maud Bodkin's Archetype Patterns of Poetry (1963), "Alph" signifies the modern need for "something enormous, ultimate, to express what strove unexpressed within experience."
>
> The Alph could be life itself, "meandering with a mazy motion" being its twists and turns. Such interpretation, in fact, subsumes the other three.

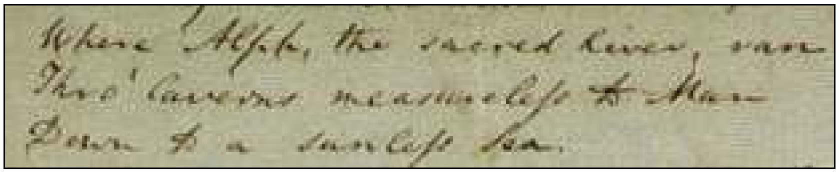
Literary scholars, of course, dissect the entire poem word by word, but we will confine our consideration to the line pertaining to subterranean waters,

> *Down to a sunless sea*

Seemingly so simple. Only five words, six syllables.

The prepositional "Down to" drop us away from the historic character Kubla Kahn and into the unconscious. "Down to" implies motion, unlike "upon" or "beneath," for example, which reflect location. Before even arriving at the "sunless," we sense a destination more ominous than one approached by ascent.

Those who quote the third word as "the," rather than "a" -- not an uncommon misrecollection -- are mistaken. We have Coleridge's draft.



Where Alph, the sacred River, ran
Thro' Caverns meaſureleſs to Man
Down to a sunleſs Sea.

The article "a" is indefinite. Were it "the," the sunless sea would be a known place, unique in space. This river's destination, however, might be one of many possibilities.

"Sunless" and "sea" alliterate, but that's common in poetry. The adjective flows into the noun, but the same can be said for many such pairs. The power of the word pair lies not in the construction, but in the image of an ocean devoid of sunlight, a vast, tumultuous elemental darkness devoid of life.

If the Alph represents life, sinking into the sunless sea must be death itself.

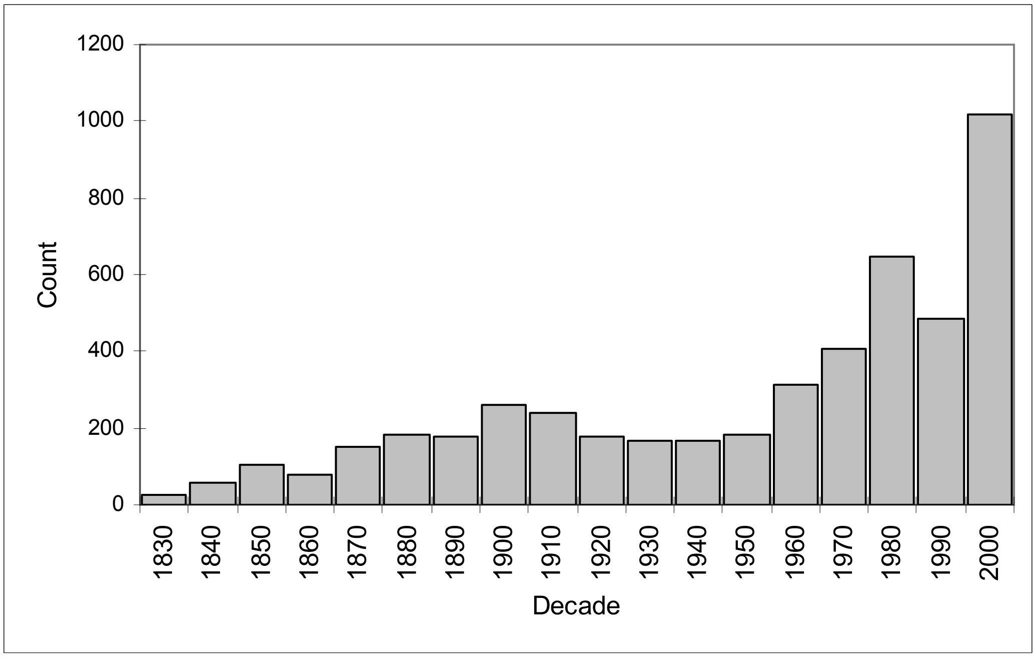
But yet the work's not morbid. While "sunless" is foreboding, a poetic "sea" holds allure. Together, there's tension.

Down to a sunless sea

Five words drawing us into the seascape within.

The Sunless Lea Legacy

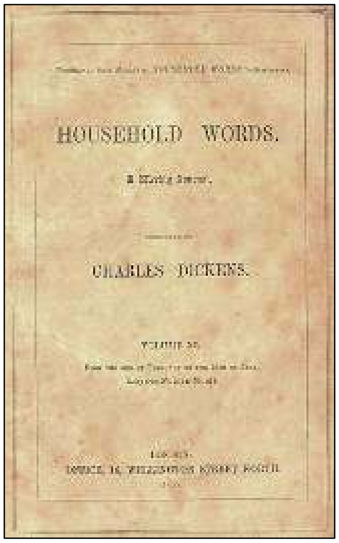
"Kubla Kahn" is included in some 2000 anthologies of English poetry and the phrase "Down to a sunless sea" is quoted in another 3000 volumes. "Sunless sea" alone is incorporated into several thousand more, but we're holding ourselves to the full phrase. The bar graph shows book publications per decade with "Down to a sunless sea" in the text.



Unlike the Chapter 19 plot of lost-world tales, "Down to the sunless sea" plot does not peak at midpoint. The phrase is cited now, more than ever before.

We'll quote from a few publications, capitalizing DOWN TO A SUNLESS SEA for emphasis, starting with The Journals of Mary Shelley: 1814-1844.

> *My imagination finds other vents -- my Kubla Khan*
>
> > *My stately pleasure house*
> > *Through which a mighty river ran*
> > *DOWN TO A SUNLESS SEA*
>
> *DOWN TO A SUNLESS SEA of oblivion which drinks any aspiration, my butterfly winged dreams which flit about my mind, illumine its recesses -- and finish an ephemeral existence, to give place to another generation.*

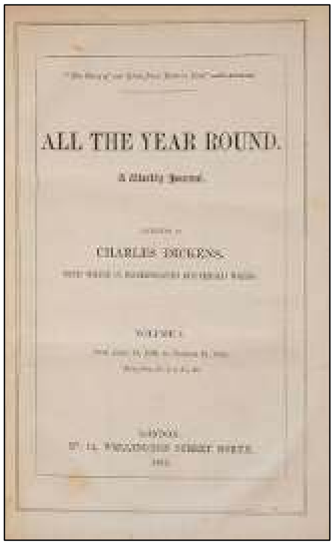


HOUSEHOLD WORDS.

CHARLES DICKENS.

George A. Sala's A Journey Due North: Being Notes of a Residence in Russia (1858) may be a bit obtuse, but Charles Dickens thought it suitable to preview in his Household Words of January 3, 1857.

> *That beefsteak and trimmings with which on board the little pyroscaphe that brought me to this Vampire Venice -- this Arabian Nightmare -- this the reality of Coleridge's distempered, opium-begotten Xanadu; (for here of a surety lives, or lived,*
>
> > *The Kubla Khan who decreed the stately pleasure dome,*
> > *And possessed the caverns measureless to man,*
> > *Through which ran that river*
> > *DOWN TO A SUNLESS SEA*
>
> *-- that beefsteak and trimmings, ruble-costing, with which coming to Xanadu -- I mean St. Petersburg -- I was incautious enough to feed the wide-mouthed Petersen, did not turn out wholly unproductive to me.*



ALL THE YEAR ROUND.

CHARLES DICKENS.

Dickens turned again to Coleridge's line in "Up and Down the Great Sun Garden," All the Year Round, August 8, 1862.

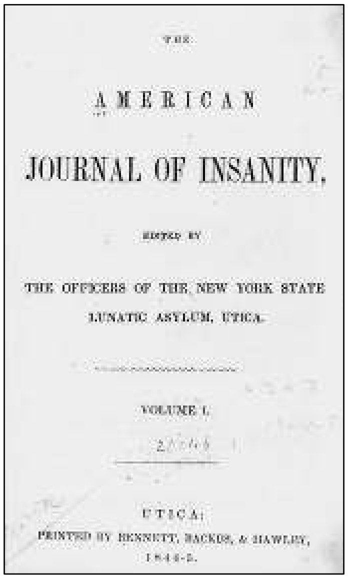
> *The travelers' first object was attained. The mountain had told its story. The river was now to be questioned. This river Limbang is the Nile of Borneo, whose sources in the far interior are yet undiscovered. The natives talked of it as a second Alph,*
>
> > *The sacred stream which ran*
> > *Through caverns measureless by man,*
> > *DOWN TO A SUNLESS SEA.*
>
> *It rushed, they declared, through miles of natural tunnel; beyond, it meandered through a seven days' journey of smooth land, peopled by tame goats without masters; but no one had been among these goats, nor visited the watery caverns.*

Henry M. Alden 's "Thomas De Quincey," published in the September 1863 Atlantic Monthly, waxes in metaphor.

> *No stream can rise above the level of its source. No life, which lacks a prominent interest as to its beginnings, can ever, in its entire course, develop any distinguishing features of interest. This is true of any life; but it is true of De Quincey's above all others on record, that, through all its successive arches, ascending and descending, it repeats the original arch of childhood. Repeats -- but with what marvelous transformations! For hardly is its earliest section passed, when, for all its future course, it is masked by a mighty trouble. No longer does it flow along its natural path, and beneath the open sky, but, like the sacred Alpheus, runs*
>
> > *Through caverns measureless to man,*
> > *DOWN TO A SUNLESS SEA.*

American Journal of Insanity (21), 1865, offers this insight on certain institutionalized patients.

> *Life to them had ceased to flow along its accustomed channel, in the light of day beneath the open sky, but ran "through caverns measureless to man, DOWN TO A SUNLESS SEA."*



THE

AMERICAN

JOURNAL OF INSANITY,

EDITED BY

THE OFFICERS OF THE NEW YORK STATE
LUNATIC ASYLUM, UTICA.

VOLUME I.

UTICA:
PRINTED BY BENNETT, BACKUS, & HAWLEY,
1844-5.

For understandable reason, the journal was later retitled the American Journal of Psychiatry.

"The Romance of an Indian Empress," Melbourne Review, January 1877, describes the Taj Mahal.

> *It exceeds in its costly grandeur and consummate perfection of architecture the wondrous structure which Artemisia erected at Halicamassus over the remains of her beloved consort, and in its fairy-like loveliness that stately pleasure-dome which Kubla Khan decreed in Xanadu,*
>
> > *Where Alf, the sacred river, ran*
> > *Through caverns fathomless by man*
> > *DOWN TO A SUNLESS SEA.*

In Chapter 51, The Tourist Trade Worldwide, we'll visit the Jenolan Caves in New South Wales. From The Jenolan Caves: An Excursion in Australian Wonderland (1889) by Sam Cooke,

> *And as you glance once more along the limestone mountain ridge you wonder what hidden beauties yet remain to be revealed. To the north from the Devil's Coach-house numerous caves are known to exist, and it is probable that some of them may present features more remarkable than any yet discovered. The creek, which runs quietly along, has on its way some oblique outlets before it sinks into the earth, and recalls, with its surroundings, the pleasure-place of Kubla Khan,*
>
> > *Where Alf the sacred river ran*
> > *Through caverns measureless to man*
> > *DOWN TO A SUNLESS SEA.*

"The Golden Fleece," by Julian Hawthorne was a adventure serialized in the Sacramento Record-Union. From September 17, 1892,

> *"I should say that her Creator had al ready done that!" said Meschines. "By the way I know a young fellow -- if he were only here -- who is just the man you want, and can be trusted. He is a civil engineer -- Harvey Freeman. The Lord only knows in what part of the world he is at this speaking. He has made a special study of these subterranean matters."*
>
> *"Don't you remember, papa, Coleridge's poem of Kubla Khan?'*
>
> > *Where Alph, the sacred river ran*
> > *Though caverns measureless to man*
> > *DOWN TO A SUNLESS SEA.*
>
> *"Our sacred river, when we find it, shall be named Miriam."*
>
> *"It ought to be Kainaiakan," she rejoined, "for, if any body finds it, it will belie."*

From the review of Juletty, A Story of old Kentucky (1901) by Lucy Cleaver McElroy, published in Publications of the Southern History Association, September 1901,

> *Here are scenes and situations which only a born story-teller-apt in word-craft by instinct and by art could vividly and sympathetically reproduce; and, as we follow these fascinating pages, reflecting, as in a mirror, the salient characteristics of the strange environment, our memory reverts to an old-time summer outing with congenial friends in that quaint, provincial region of mystery and charm a land of soft sunshine, of broad and fertile ranges; of noble woodlands; of soft-flowing waters ; of dewy meadows ; of fields of maize and gardens of fruits and (lowers ; of great silent streams mirroring the slow raft or the swift canoe ; of strange relics of vanished races known only by their entombed remains; of mighty caverns patiently wrought by crude cosmical agencies into chambers and corridors of sculpturesque finish and grace; of mysterious rivers, untouched by human traffic, flowing ceaselessly in subterranean silence,*
>
> > *Like Alph, the sacred river,*
> > *DOWN TO A SUNLESS SEA.*

As the "Testing Flow of Underground River," St. Louis Republic, December 26, 1902, concerns groundwater, we could include it in Chapter 46, Finding the Underground Rivers, but we'll cite it here for its poetic reference.

> *The Arkansas River in Western Kansas flows for a distance underground, and the corps has used an electrical device to find the velocity of the subterranean current. A row of wells is driven across the channel at regular intervals. An electrolyte is sunk in one of the upper wells and allowed to dissolve. As the solution passes down to the other wells a needle of an electrical instrument is deflected. Thus it is shown that the Arkansas flows two and one-half feet a day under ground. The time may come when the Government survey will investigate that dream river of Coleridge, who sang,*
>
> > *In Xanadu did Kubla Khan*
> > *A stately pleasure dome decree,*
> > *Where Alph, the sacred river, ran*
> > *Through caverns measureless to man*
> > *DOWN TO A SUNLESS SEA.*

We delight in poet Walt Mason's closing lines of "The Funeral" (1911).

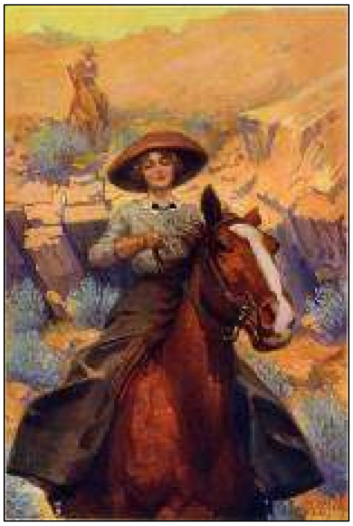
> *So when I up and trundle DOWN TO A SUNLESS SEA,*
> *Let no one blow a bundle to pay for planting me.*
>
> *I'll slumber just as sweetly in some old basswood box,*
> *As though trussed up completely with silver screws and locks.*

In Chapter 51 we'll visit the Lebanese Jeita Caves described by Lewis Gaston Leary in Syria, The Land of Lebanon (1913).

> *With the aid of portable rafts, adventurous explorers have penetrated this wonderful cavern for nearly a mile; but at that distance there was no diminution of the volume of the stream or any*

> *other indication that they had come at all near to the source of the mysterious underground river. The light of their torches but dimly revealed the roaring torrent ceaselessly speeding out from dark, distant channels like those*
>
> *Where Alph, the sacred river, ran*
> *Through caverns measureless to man*
> *DOWN TO A SUNLESS SEA.*

Robert Bennet's Out of the Depths: A Romance of Reclamation (1913) provides a platform from which to promote engineering.



> *"It's sure some canon," admitted her husband. "That French artist Doré ought to have seen it."*
>
> *"If only we had a copy of Dante's Inferno to read here on the brink!" she whispered.*
>
> *"It always reminds me of Coleridge's poem," murmured Isobel, and she quoted in an awed whisper:*
>
> *Where Alph, the sacred river, ran*
> *Through caverns measureless to man,*
> *DOWN TO A SUNLESS SEA.*
>
> *"Fortunately for us, this is a canyon, not a string of measureless caverns," said Blake. "It can be measured, one way or another. If I had a transit, I could calculate the depth at any point where the water shows -- triangulate with a vertical angle. But it would cause a long delay to send on for a transit. We shall first try to chain down at that gulch break."*

"Adventures in a Cavern," Outing, October 1914-March 1915, by Horace Kephart, reports "What Two Men Found in One of Earth's Secret Places Among the Ozark Hills."

> *But there is a fascination in solving the mystery of what has lain for untold ages beyond human ken; in venturing, as we were about to venture, where no foot of man has ever trod. What was there within these forbidding arches? Vast chambers, perhaps hung with weird pendants, walls glittering with crystals, forests of stalagmites, columns of alabaster or of "onyx." There might be relics of prehistoric races buried in stone since some past geological epoch, petrifactions of plants and animals that died ages before man was born, living species unknown to the upper world. There might be dripping springs trickling through crannies in the rock, rills rumbling from ledge to ledge in fairy waterfalls and gathering far below in some subterranean stream that ran*
>
> *Through caverns measureless to man*
> *DOWN TO A SUNLESS SEA.*

"Prehistoric Remains (Forts and Dolmens) in Burren and Its South Western Border, Co. Clare," Journal of the Royal Society of Antiquaries of Ireland 5:1, March 31, 1915, is a droll geographic piece by Thomas Westropp, but such can be spiced up by poetic reference.

> *There the fissured grey crag, level as a pavement, shelters in its clefts the hartstongue and maidenhair ferns. There the underground stream runs "DOWN TO A SUNLESS SEA."*

"The Humanizing of Knowledge," Science, July 28, 1922, undertakes "to introduce the scientist to himself," a formidable task, indeed. Quotations within the passage below, other than that from Kubla Kahn, are from Alfred Tennyson.

> *Among the wonderers and pointers-out the poet, who "fancy light from Fancy caught," whose "thought leapt out to wed with thought," has always been surest of a large audience. For songs, heroic tales and rhapsodies can be attuned to the heart's desire-they are magic carpets*

on which we can voyage whither we will. Their truth is the deepest truth, that of vague human longings. When we are told that

Kubla Khan a stately pleasure dome decreed,
Where Alph the sacred river ran,
Through caverns measureless to man,
DOWN TO A SUNLESS SEA,

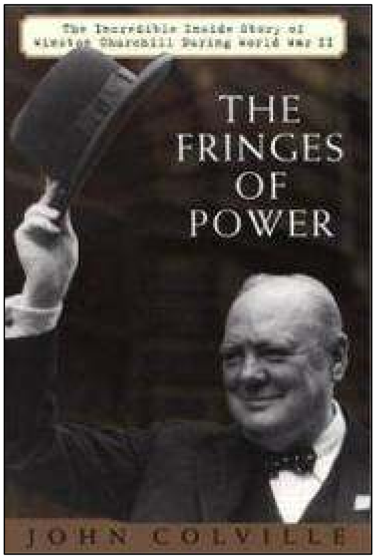
we do not feel obliged to consult a list of Tartar rulers, or locate the sources of the river Alph, or consider the geological formation of limestone caverns. Few will be disturbed by the question of what particular species of wood louse secreted the honey dew, or the probable number of bacteria occurring per cubic centimeter in fresh milk of Paradise.

Sir John Colville was a British civil servant and diarist. From his January 1944 entry, The Fringes of Power: The Incredible Inside Story of Winston Churchill during World War II (2002),

We had a picnic in glorious country at a place called Pont Naturel. There was a deep gorge through which a stream ran, falling from rock to rock into limpid blue pools. Lady Diana [Cooper] *gave one look at it and said Alph! The P.M.* [Churchill] *insisted on being carried down and scrambling over the rocks.*

"Alph" is footnoted,

In Xanadu did Kubla Khan
A stately pleasure dome decree:
Where Alph, the sacred river, ran
Through caverns measureless to man
DOWN TO A SUNLESS SEA.
Coleridge


The Incredible Inside Story of Winston Churchill During World War II
THE FRINGES OF POWER
JOHN COLVILLE

Lady Diana's exclamation, not otherwise explained, reflects her literary upbringing. The footnote evidences Sir John's concern that less-gentile readers might not recognize the source.

From Richard Jefferies and his Countryside (1946) by Reginald Arkell,

Into it flowed the River Nile, crawling with alligators, and out of it the Mississippi ran,

Through pastures measureless to man,
DOWN TO A SUNLESS SEA.

Standing, like stout Cortez, upon some lonely peak, the islands of New Formosa and Serendib were just visible through the fret and spume of the New Sea. Strange birds and stranger beasts stirred the rushes that ran down to the water's edge.

From Kathleen Raine's "The Sea of Time and Space, Journal of the Warburg and Courtauld Institutes 20:3/4, July-December, 1957,

The cave is, in fact, the place of generation, where the mystery of the descent of souls takes place in its womb-like depths, where perpetually flowing waters are the sacred source of generated existence. The river of life rises in the most secret depths of the world-cave, and like

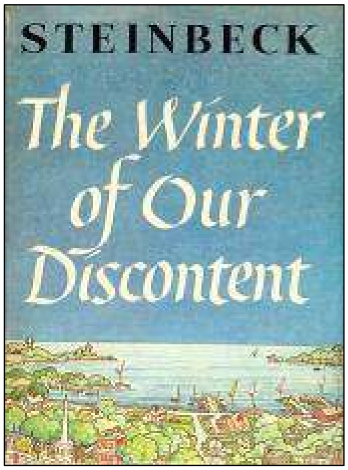
Alph, the sacred river, runs
Through caverns measureless to man,
DOWN TO A SUNLESS SEA"

Footnoted,

> *There can be no doubt that Coleridge, familiar as he was with the Neoplatonists, had this symbolism in mind when he wrote of his river, descending from a Paradisical world, through caverns, to a "sunless sea" -- sunless because this is a world of spiritual darkness.*

From The Winter of Our Discontent (1961) by John Steinbeck,

> *I just know when a man is looking for me, or some other Margie. Watch the stairs, they're narrow. Don't hit your head at the top. Now, here's the switch -- you see? A pleasure dome, soft lights, smell of musk -- DOWN TO A SUNLESS SEA.*



Juxtaposition (1963) by Piers Anthony is fantasy fiction.

> *He went on DOWN TO A SUNLESS SEA and huddled in the diminishing current as the last of the water drained out the bottom. Maybe the enchantress, whoever she was, really did mean to help him, since she knew he would die if she didn't.*

Kathleen Raine's "Blake's Debt to Antiquity," Sewanee Review 71:3, Summer 1963, is literary criticism.

> *From the secret depths, water perpetually flows, and, like*
>
> *Alph, the sacred river, runs*
> *Through caverns measureless to man,*
> *DOWN TO A SUNLESS SEA of matter:*
>
> *sunless because remote from spiritual light and, as Blake shows it, storm-tossed.*

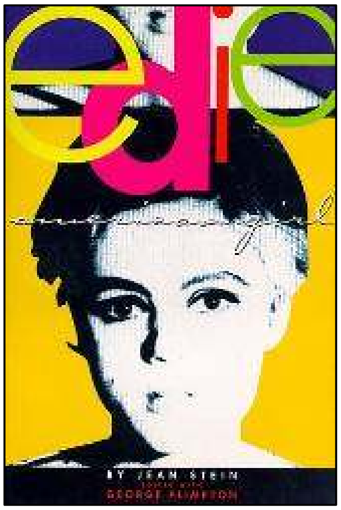
Colleen McCullough's A Creed for the Third Millennium (1986) may be forgotten in a much shorter period, but there's still the nod to Coleridge,

> *A political appointee, he came with the a new President, was never a career public servant himself, and went through a predictable sequence from new broom to worn-out stubble -- if he lasted in the job. Well, Harold Magnus had lasted, and lasted for the usual reason; he possessed the good sense to let his career people get on with their jobs, and on the whole was secure enough within himself not to be causelessly obstructive.*
>
> *"DOWN TO A SUNLESS SEA," she said into the speaker buried in the outside wall.*
>
> *The door clicked and swung open. Crap. Useless shit. No one in the world could have duplicated her voice well enough to fool the electronics analyzing it, so why have a changing password?*

From To Blight with Plague: Studies in a Literary Theme (1993) by Barbara Leavy,

> *But if Poe's works create fable in the mind, as Dayan convincingly argues, then the most important lines in Coleridge's poems are not those that Poe draws on for his own landscapes of the mind, but rather the destination of Coleridge's waterway:*
>
> *The sacred river, ran*
> *Through caverns measureless to man*
> *DOWN TO A SUNLESS SEA.*

Edie, of Jean Stein's Edie: American Girl (1994), recalls the poem.



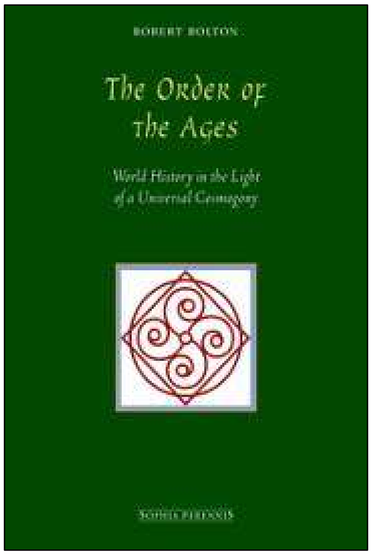
> *You can actually hear the wind in the pines, which is a completely different sound than oak trees or just no trees at all. It's a beautiful sound. I love it. And I know that there were only two places on the ranch that you could go and really listen to it. It was music. And what else was there? Oh, there were the Uplands, and that's where Edie wanted to stay. That was dangerous in a storm. So much violence. The ranch was potential violence -- both human and natural.*
>
> *Do you know Coleridge? "Kubla Kahn?"*
>
> > *In Xanadu did Kubla Khan*
> > *A stately pleasure dome decree:*
> > *Where Alph, the sacred river, ran*
> > *Through caverns measureless to man*
> > *DOWN TO A SUNLESS SEA.*
>
> *The ranch was all these things and, boy oh boy, does Coleridge know what he's taking about.*

Likewise, the main character of Valerie Malmont's Death, Snow, and Mistletoe (2000) remembers the lines.

> *Curious about where it went, I got out of the truck to take a look. Along the base of the building were several arches, about three feet high, covered with wire mesh. To look through one, I knelt on the cracked macadam parking lot and saw that beneath the building the creek spread out into a huge tar-black lake. There was no way to tell how deep it was, but the water was so still and dark it gave the appearance of being bottomless.*
>
> *My favorite childhood poem by Coleridge came to mind and I recited,*
>
> > *Where Alph, the sacred river, ran*
> > *Through caverns measureless to man*
> > *DOWN TO A SUNLESS SEA.*
>
> *It was here that Bernice had dreamed of building her "stately pleasure dome."*

We included snippet from the poem "Darkened" by Douglas Wilson, Untune the Sky: Occasional, Stammering Verse (2001),

> *Oblique, opaque, and never ending*
> *Poets wander, ever wending*
> *DOWN, STILL DOWN, TO A SUNLESS SEA.*

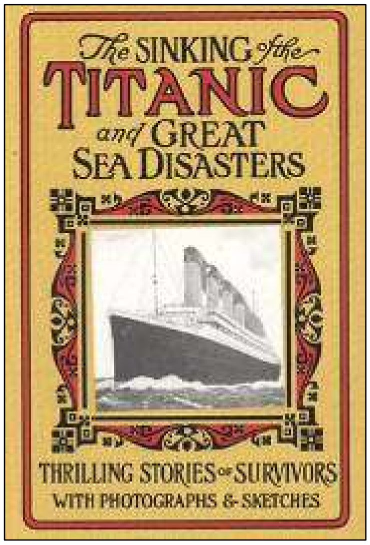


The Order of the Ages: World History in the Light of a Universal Cosmogony (2001) by Robert Bolton and Charles Upton tends toward the occult.

> *Consequently, this ontological movement has its reverberation in the subconscious mind, where it well may have inspired Coleridge's lines:*
>
> > *Where Alph, the sacred river, ran*
> > *Through caverns measureless to man*
> > *DOWN TO A SUNLESS SEA.*
>
> *The "sunless sea" would therefore be the material world in which the Forms reach their final level of instruction. The more usual interpretation, that is an allusion to the river of Paradise manifested, in a relative sense at least, the fount of realities which make up this world.*

Gravelight (2003) by Marion Zimmer Bradley includes,

> *DOWN TO A SUNLESS SEA. The phrase circled around inside Wycherly's brain as if it were the answer to all Life's riddles. DOWN TO THE SUNLESS SEA... It was a line from a poem, but he no longer remembered which one.*
>
> *He hadn't brought the flashlight, but it didn't matter. His hand trailed along the curving rock wall, and Wycherly moved slowly, inexorably, down the stairs. DOWN TO A SUNLESS SEA.*
>
> *All he could hear was water: tricking, roaring, gushing, purling on from nowhere to nowhere, down here in the dark. Tickling scraps of spider webs brushed his face, and he batted them away absently.. DOWN TO A SUNLESS SEA. He did not have to ask where he was going -- he knew.*


The SINKING of the TITANIC and GREAT SEA DISASTERS
THRILLING STORIES OF SURVIVORS
WITH PHOTOGRAPHS & SKETCHES

For dire maritime statistics, we have Sinking of the Titanic and Great Sea Disasters (2004) by Logan Marshall.

> *As long ago as 1841, the steamer President, with 120 people aboard, crossing from New York to Liverpool in March, vanished from human ken. In 1854, in the same month, the City of Glasgow left Liverpool for Philadelphia with 480 souls, and was never again heard of. In February, 1856, the Pacific, from Liverpool fro New York, carrying 185 persons, passed away DOWN TO A SUNLESS SEA. In May 1870, the City of Boston, from that port for Liverpool, mustering 191 souls, met a similar fate.*

Bedlam's Edge (2005) by Mercedes Lackeyand and Rosemary Edghill returns us to the surreal.

> *Ahead, silver stones were laid into a smooth, broad oath, and the path led to what must be a palace, although that could not bee seen through the intricate metal gates of a high wall was a fantastic Arabian Nights entrance, and above the walls dozens of gold-domed minarets. Along*

> *the path was a river of smooth, dark water that ran in under the gate in the palace wall and all around the buildings behind the wall. A lifted drawbridge hovered over the water.*
>
> *"Oh, my," Dov said.*
>
> *And Rivka breathed,*
>
> *In Xanadu did Kubla Khan*
> *A stately pleasure dome decree:*
> *Where Alph, the sacred river, ran*
> *Through caverns measureless to man*
> *DOWN TO A SUNLESS SEA*

Divine Madness: Archetypes of Romantic Love (2010) by John R. Haule, on the other hand, brings us back to introspection.

> *Alph, the sacred river, runs*
> *Through caverns measureless to man*
> *DOWN TO A SUNLESS SEA.*
>
> *It is the source of our deepest unconscious longings and images. When it is "flung up momently" to the surface, consciousness becomes flooded with its primordial darkness -- but also with the long hidden mysterious of that underworld of the psyche.*

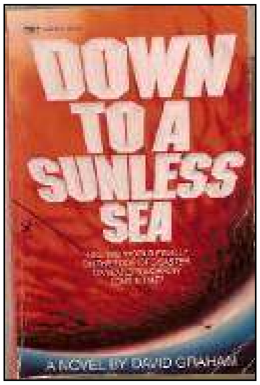
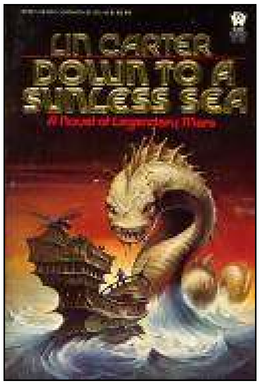
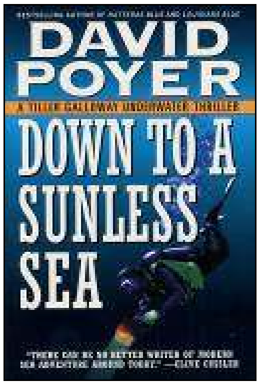
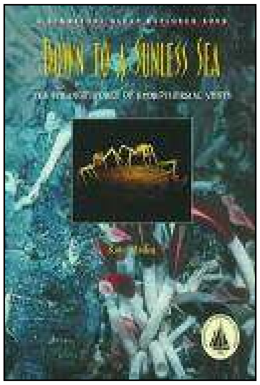
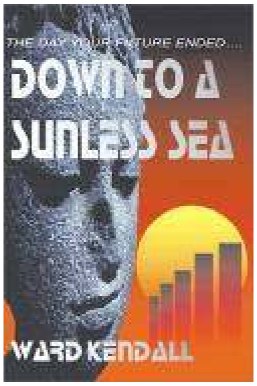
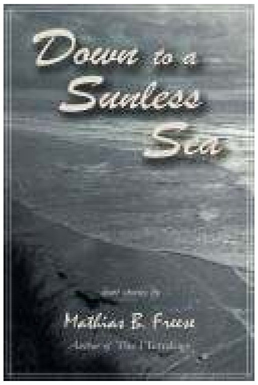
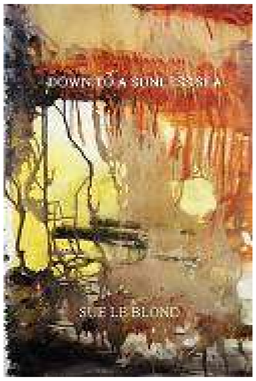
In Nature Mysticism: A Guide (2010), J. Edward Mercer argues for transcendence.

> *But are such experiences possible for the modern mind? Yes, if we can pierce through the varied disguises which the institutional material assumes as times and manners change. Coleridge, for example, is thrown into a deep sleep by an anodyne. His imagination takes wings to itself; images rise up before him, and, without conscious effort, find verbal equivalents. The enduring substance of the vision is embedded in the fragment, "Kubla Kahn," the glamour of which depends chiefly on the mystical appeal of subterranean waters. We are transported where*
>
> *Alph, the sacred river, ran*
> *Through caverns measureless to man,*
> *DOWN TO A SUNLESS SEA.*
>
> *These three lines make deeper impression than any others in the poem, and form its main theme.*
>
> *Nor is the feeling of the supernatural unrecognized. Spirits are near with prophetic promptings. From a deep ocean the sacred river throws up a mighty fountain, and for a short space wanders through wood and dale, only to plunge again into its measureless caverns, and sink in tumult to a lifeless ocean.*

And again back to pulp fiction. From A Dance with Dragons (2011) by George R.R. Martin,

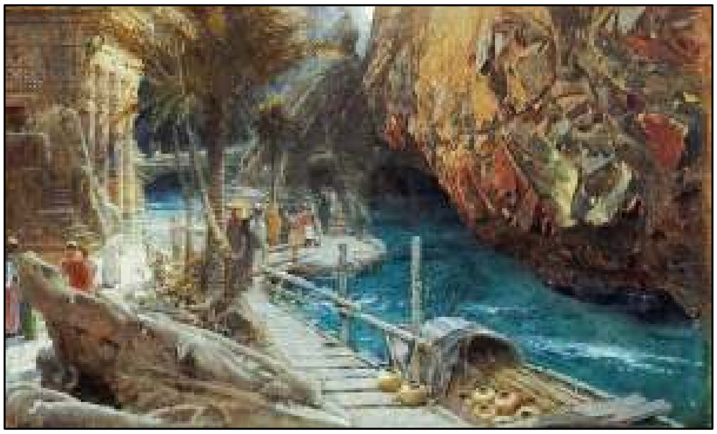
> *The caves are timeless, vast silent. They were the home to more than three score living singer and the bones of thousands dead, and extended far below the hollow hill. "Men should not go wandering in this place," Leaf warned them. "The river you hear is swift and black, and flows DOWN TO A SUNLESS SEA. And there are passages that go even deeper, bottomless pits and sudden shafts, forgotten ways that lead to the very center of the earth."*

A few recent Sunless Sea book covers,

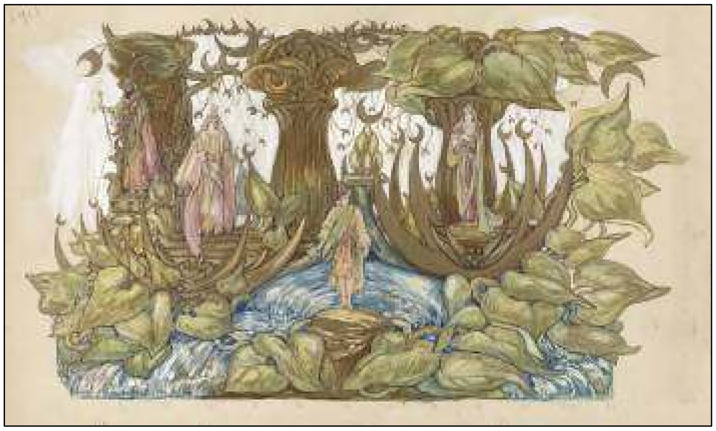
 David Graham (1979)	 Lin Carter (1984)	 David Poyer (1996)	 Kate Madin (1999)
 Ward Kendall (2000)	 Mathias Freese (2007)	 Daniel McGowan (2007)	 Sue Le Blond (2008)

Coleridge's sunless sea poses an artistic challenge, as the verbal imagery does not lend itself to fixed lines and static shapes.

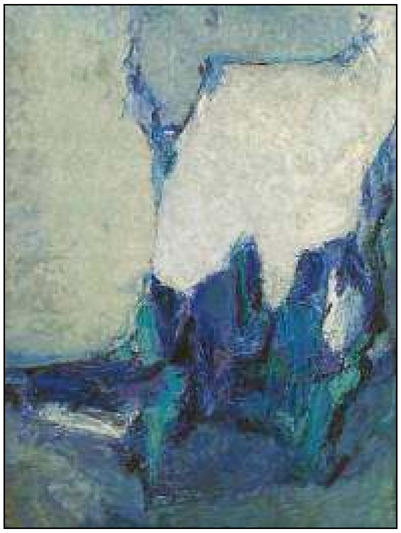
To the right is Albert Goodwin's effort, "The Source of the Sacred River" (c. 1900).



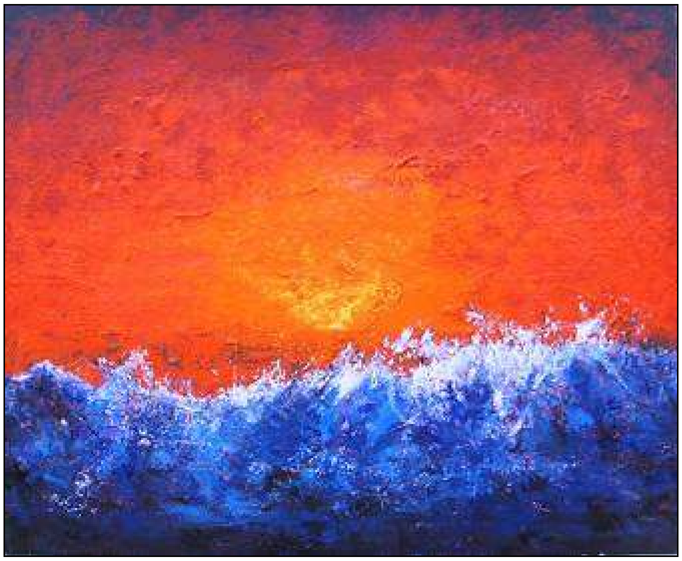
Here we have "In Xanadu Did Kubla Khan," a float design for the Mistick Krewe of Comus parade, New Orleans Marti Gras, 1911.



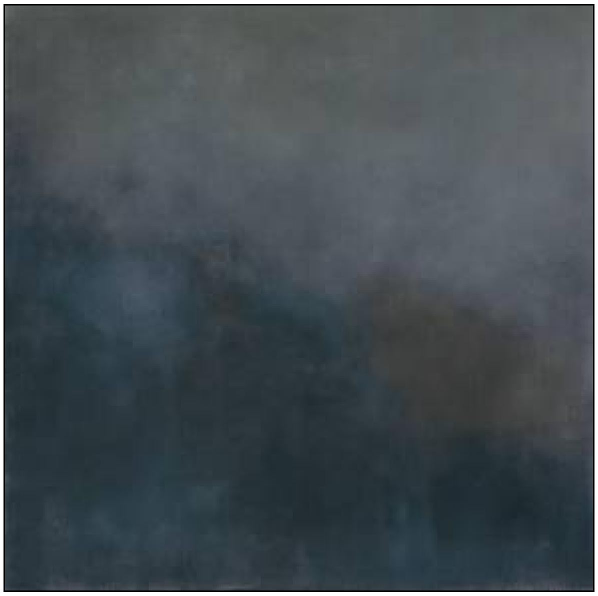
Following are four contemporary works. Not all artists share the same vision, the very reasons we have art.



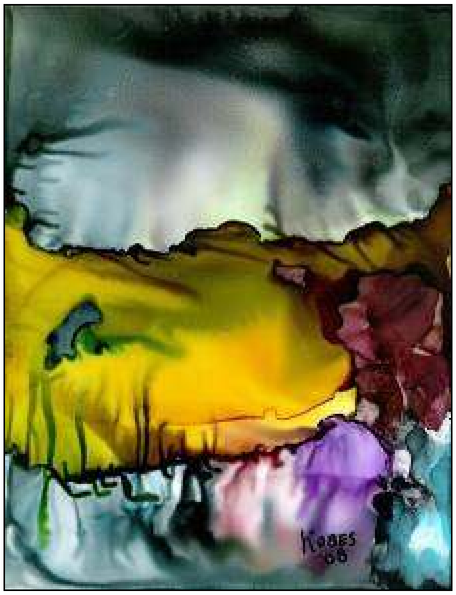
"Down to the Sunless Sea,"
Mary Ray Gehr



"Down to a Sunless Sea," Tony Broadbent

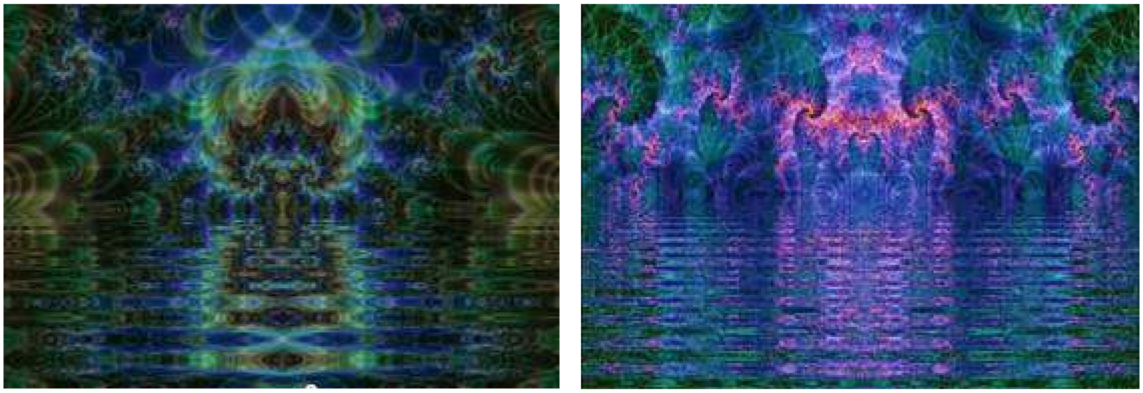


"Down-to Sunless Sea," Linda J Ging

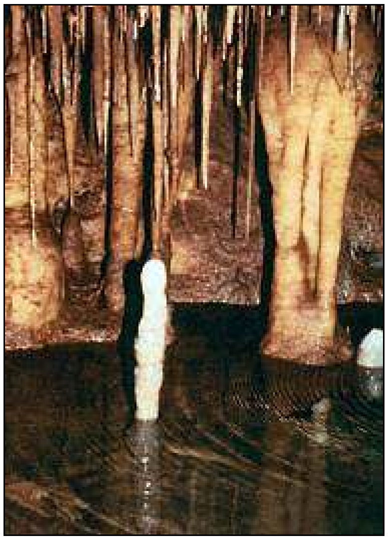


"Sunless Sea," Susan Kubes

"Fractal Xanadu" (2008), a video by Abysimus, employs digital imagery for a morphing impressionistic visualization.



There is, in fact, a physical "Sunless Sea," but there's not much of it. Arizona's Kartchner Caverns' 19-meter crowned column, "Kubla Kahn," is touted for both its majesty and its mystery. Water in the cave's depths would be by association, the Sunless Sea, but other than at times of seasonal infiltration from the surface, it's mostly mud flats.



Kartchner
Caverns
$22.95

Our journeys to sunless seas have been varied, but each has taken us to waters less illuminated, more internal. Of all sunless seas, Coleridge's vision ranks the most compelling.

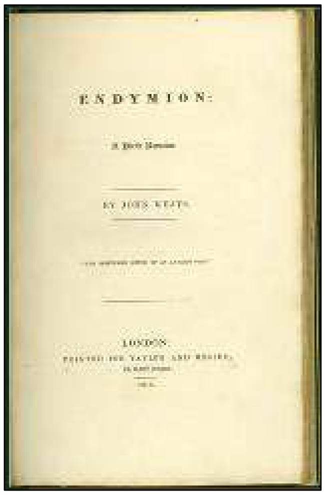
CHAPTER 31

POEMS FOR SUBTERRANEAN SAILORS

"Kubla Kahn," as we noted in the previous chapter, stands high in English poetry, but there's a great amount of other verse about underground rivers. We'll assemble just a sample.

"Endymion" (1818) by **John Keats** speaks of underground rivers.

Through caves, and palaces of mottled ore,
Gold dome, and crystal wall, and turquois floor,
Black polish'd porticos of awful shade,
And, at the last, a diamond balustrade,
Leading afar past wild magnificence,
Spiral through ruggedest loopholes, and thence
Stretching across a void, then guiding o'er
Enormous chasms, where, all foam and roar,
Streams subterranean tease their granite beds;
Then heighten'd just above the silvery heads.



ENDYMION:

BY JOHN KEATS

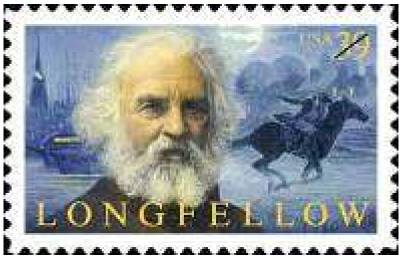
LONDON:

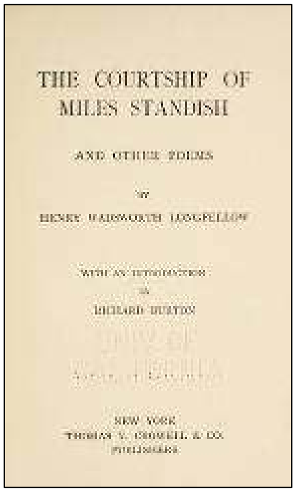
"The Close of the Year" (1840) by **George D Prentice**,

Weep not that Time
Is passing on -- it will ere long reveal
A brighter ere to the nations. -- Hark!
Along the vales and mountains of the earth
There is a deep, portentous murmuring,
Like the swift rush of subterranean streams.

We've a pair from **Henry Wadsworth Longfellow**. "To a Child" (1841) wasn't what today is known as juvenile poetry.

Freighted with hope and fear;
As upon subterranean streams,
In caverns unexplored and dark,
Men sometimes launch a fragile bark,
Laden with flickering fire,
And watch its swift-receding beams,
Until at length they disappear,
And in the distant dark expire.




THE COURTSHIP OF
MILES STANDISH

AND OTHER POEMS

BY

HENRY WADSWORTH LONGFELLOW

WITH AN INTRODUCTION
BY
RICHARD BURTON

NEW YORK
THOMAS Y. CROWELL & CO.
PUBLISHERS

There's a subterranean river in Longfellow's The Courtship of Miles Standish (1858).

> *Hence is the inner life of so many suffering women*
> *Sunless and silent and deep, like subterranean rivers*
> *Running through caverns of darkness, unheard, unseen, and unfruitful,*
> *Chafing their channels of stone, with endless and profitless murmurs.*

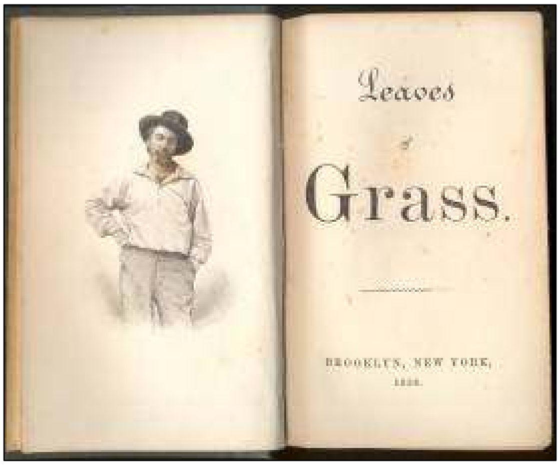
D. Parish Barhydt's "Ahyunta" (1851) is notable for its footnote.

> *Florida, rich are thy beauties and varied thy charms,*
> *Where sweetest emotions are strung with alarms.*
> *Seeming lakeletts of steel there empolish the plain,*
> *Beware the dark sink! it is fathomed in vain;**
> *There earth wears a smile, but is hollow below,*
> *And swift sunless rivers through wide caverns flow.*

> ** The author became acquainted in Florida with the sudden recession of a large lake from its banks to great an extent (nearly draining it entirely), that it could only be accounted for on the hypothesis that a sudden caving of its bottom had opened a passage into the cavernous depths below. He was also familiar with a legend of an Indian entering by chance a cave in the bank of one river, and after dark and tortuous wanderings therein, emerging upon the bank of another many miles distant.*

We'll become better acquainted with the "cavernous depths below" Florida in Chapter 40, Sinkholes.

Walt Whitman's Leaves of Grass (1855) includes the poem "As Consequent, Etc.," a portion of which follows.



As consequent from store of summer rains,
Or wayward rivulets in autumn flowing,
Or many a herb-lined brook's reticulations,
Or subterranean sea-rills making for the sea,
Songs of continued years I sing.

UNITED STATES POSTAGE
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WALT WHITMAN

Whitman's hydrology is, in fact, more accurate than some of his era's scientific teaching. And while we're discussing Whitman, though it's not poetry, we'll cite "The Spanish Element in our Nationality" (1883), in his Complete Prose Works (1891).

> *As to the Spanish stock of our Southwest, it is certain to me that we do not begin to appreciate the splendor and sterling value of its race element. Who knows but that element, like the course of some subterranean river, dipping invisibly for a hundred or two years, is now to emerge in broadest flow and permanent action?*

We'll visit the San Marcos in Texas in Chapter 48, Diversity in Darkness, Texan Ecology, but here we'll meet the river poetically. From the Library of Southern Literature 3, 1909,

> *Robert Lewis Dabney's fame in literature will rest, and justly so, on his work in prose* {he was the biographer to Stonewall Jackson}*, yet in leisure hours he turned aside to poetry and produced verses, some of which are not unworthy of preservation as witness the opening lines of his poem, "The San Marcos River"*

Mysterious river! Whence thy hidden source?

The rain-drops from far distant field and fell,
Urging through countless paths their darkling course,

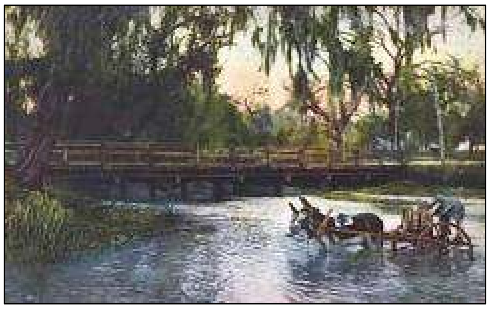
Combine their tiny gifts thy flood to swell.
What secrets hath thy subterranean stream

Beheld; as it hath bathed the deepest feet
Of everlasting hills, which never beam

Of sun or star or lightning's flash did greet?
Over what cliffs rushed thou in headlong fall

Into some gulf of Erebus so deep
Thy very foam was black as midnight's pall

And massive roof of rock and mountain steep
Suppressed thy thunders, so that the quick ears



Of fauns recumbent on its lofty side
Heard not; and grass-blades laden with the tears

Of night dews, felt no quiver from thy tide?
Through days and weeks uncounted by the sun,

Thy waters in abysmal caves have lain
In slow lustration, ere they sought to run

Forth to the day, purged from earth's least stain.
Pallas-Athene of the rivers, thou!

Who leapest adult in thy glittering might
From yonder hoary mountain, Zeus's brow,

Whose cloven crags parted to give thee light.
Thou teachest us, wise virgin; as through caves,

Sad and tear-dropping, steal thy sobbing waves,
Then flash to day; so Virtue's weeping night

Shall surely break into the dawn's delight.

We will simply note that a century later, Dabney's biography of the Confederate hero remains in print, but his poetry is absent from current anthologies.

In " and the Death of Lady Gregory," Irish University Review, March 22, 2004, Roy F. Foster critiques **W.B. Yeats**' "Coole Park and Ballylee" (1931) which begins,

Under my window-ledge the waters race,
Otters below and moor-hens on the top,
Run for a mile undimmed in Heaven's face
Then darkening through 'dark' Raftery's 'cellar' drop,
Run underground, rise in a rocky place
In Coole demesne, and there to finish up
Spread to a lake and drop into a hole.
What's water but the generated soul?

and ends.

Though mounted in that saddle Homer rode
Where the swan drifts upon a darkening flood.

WILLIAM BUTLER YEATS
5P ÉIRE

According to Foster,

The lake, its underground river, his own Tower (effectively abandoned four years previously but now reoccupied for poetic purposes), and the house at Coole are linked by the eternal image of a soaring swan, which in turn suggests the journey of the soul (signaled by an implicit reference to the Neo-Platonist Porphyry in the first verse). But it is also, he privately told his wife, 'a symbol of inspiration'. All the house and its chatelaine had meant to him is concentrated into a poem that should also be read as another installment in his mounting commentary on the Anglo-Irish tradition and its importance for modern Irish life.

"In Praise of Limestone" (1948) by **W.H. Auden** is geologically specific about its underground stream.

The blessed will not care what angle they are regarded from,
Having nothing to hide. Dear, I know nothing of
Either, but when I try to imagine a faultless love
Or the life to come, what I hear is the murmur
Of underground streams, what I see is a limestone landscape.

According to Margaret Rees' World Socialist internet posting,

> *The second half of the poem assumes a languid conversational tone, mildly self-mocking and tentatively disparaging the landscape. An invocation to the natural order is decried, the concept of purity ebbs away in a neat didactic couplet. What is left is sediment.*

Although we may lack the erudition to agree or disagree with Ms. Rees, we must be impressed with the fact that water in limestone caverns is known to poets.

Felicia Dorothea Browne Hemans' "Subterranean Streams" (1854) is a poem of the type suitable for a parlor game in which a stanza is read, all but the last word, which the players rush to guess. Give it a try.

Darkly thou glidest onward,
Thou deep and hidden wave!
The laughing sunshine hath not looked
Into thy secret ______.
Thy current makes no music
A hollow sound we hear,
A muffled voice of mystery,
And know that thou art ______.
Yet once will day behold thee,
When to the mighty sea,
Fresh bursting from their caverned veins,
Leap thy lone waters ______.

There wilt thou greet the sunshine
For a moment, and be lost,
With all thy melancholy sounds,
In the ocean's billowy ______.
Wild is their course and lonely,
And fruitless in man's breast;
They come and go, and leave no trace
Of their mysterious ______.
Yet surely must their wanderings
At length be like thy way;
Their shadows, all thy waters, lost
In one bright flood of ______!

The answers: cave, near, free, host, guest, day

Not all underground river poetry lends itself to parlor entertainments, however. Take, for example **Moikom Zeqo**'s "The Miracle of Death," translated from the original Albanian by Wayne Miller.

The miracle of death is precise like the law.
Our bodies will decompose in their natural elements.
Perhaps we'll meet as underground streams,
As humus and salt at the roots of a plant
That will flourish and open its petals,
Astounding everything with its anonymous ______.

The answer (difficut for those not fluent in Albanian): "beauty"

James Dickey's poems are infused with anxiety and guilt upwelled by the memory of his brother who died before Dickey was born. In "The Underground Stream" (1960) Dickey peers into a well, seeking how his spirit could fall through the pool to find reconciliation with his sibling.

I lay at the edge of a well,
And thought how to bury my smile
Under the thorn, where the leaf,
At the sill of oblivion safe,
Put forth its instant green
In a flow from underground.
I sought how the spirit could fall
Down this moss-feathered well.
The motion by which my face,
Could descend through structureless grass,
Dreaming of love, and pass
Through solid earth, to rest
On the unseen water's breast,
Timelessly smiling, and free
Of the world, of light, and of me.

Photography by J. Via

Pulitzer Prize winner **Maxine Kumin** writes of nature's persistence in ”Why There Will Always Be Thistle” (2001).

Outlawed in most Northern
states of the Union
still it jumps borders.
Its taproot runs deeper
than underground rivers
and once it's been severed
by breadknife or shovel
-- two popular methods
employed by the desperate --
the bits that remain will
spring up like dragons' teeth
a field full of soldiers
their spines at the ready.

Algimantas Baltakis' "Underground Rivers" is not at all about symbolism. It's an accurate description.

Alas, these rivers have no names.
No banks have they to shape their frames.
They don't reflect the floating sky,
In gloom by day and night they lie.
A wild sea-mew will never sweep
Across their waters running deep
Nor will a maiden ever chance
To see dawn glow on their expanse.
Yet their dim waters, cool and clear,
Feed wells and fountains far and near.
In summer drought or winter frost
Their patient streams are never lost.
Oppressed by darkness, now and then
The waters try to leave their den.
In dense dark forest look around,
A spring is bubbling from the ground.

Andriana Škunca's "Shadow," on the other hand, could be about anything that haunts us.

Farther away it gushes out of the underground stream,
  Following us everywhere.
Constantly tied to some suffering that resides in us
  Like a broken staff it leans on.

Here's a twelfth century Japanese verse published in the November 5, 1921, Literary Digest.

The subterranean river takes its rise
And flows unseen beneath the hills.
Like this, my love; and I indeed am sad
Because I may not tell my love.

Charles Pierre Baudelaire's (1821-1867) name has become a byword for literary and artistic decadence. His "Don Juan aux Enfers" (Don Juan in Hell) centers around a free-thinking Spanish nobleman who seduces a woman, kills her father and then insults the dead man's statue before being condemned to hellfire.

When Don Juan reached that underground river,
He paid his death coin passage from those shores.
Charon, gruff in Antisthenes' manner,
Then pulled with vengeful arms on his long oars.

And our anthology of underground river poetry -- some by title, others by usage -- just keeps going. Here are a few more, sans comments.

Rosemarie Johnstone	"An Underground River in West Hollywood" (2001)	*If I were not such a lazy scholar disinclined to supplement* *Assigned of this hill startling emerald green*
Jane Reichhold	"Waves/Above the Underground River" (1990)	*Waves* *Above the underground river* *Sand dunes* *Plain as the lighted face* *Pilled with love radiating*
Phillis Levin	"A Meeting of Friends" (1988)	*Although their hair is turning gray* *And love is a stream changing course underground.*
Margaret Holley	"The Gallery of Owls" (1993)	*The river running underground* *Who am I then?* *Three snowy owls.* *Firelight on walls*
B.P. Shillaber	"A Song," (1853)	*The thirsty mart feels through its heart* *The mighty current quiver,* *Through streets and lanes, in iron veins,* *A subterranean river.*
Constance Henriette Urdang	"The River" (1990)	*Even here we have driven the river underground* *Like a blind man on an unfamiliar street* *Tapping his path between strangers*
Grace Butcher	"Sunbathing" (1967)	*The sun carves* *my body into caves* *where bird song moves* *like an underground stream.*
Theodore Roethke	"The Cycle" (1965)	*Dark water, underground* *Under a river's source* *Under primeval stone*
James Galvin	"Leap Year" (2003)	*When the river goes underground* *It isn't lying* *Home is where the heart gives out* *And we arouse the grass*
Muriel Rukeyser	"Letter to the Front" (1994)	*Women and poets see the truth arrive* *The blind inventor finds the underground river*
Muriel Rukeyser	"Women and Poets See Truth Arrive" (2004)	*Then its is acted out* *The blind inventor finds the underground river*
Lyn Lifshin	"That July" (1997)	*Something under skin* *Underground streams*

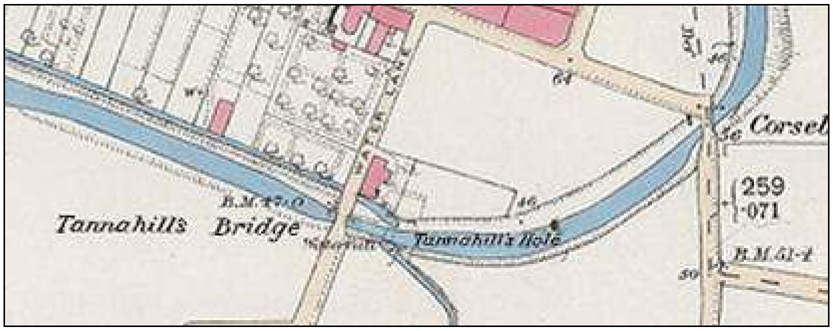
But where, we may ask is Carl Sandburg?

The answer doesn't lie in this chapter because, alas, we've yet to find a Sandburg poem about underground rivers. But that's not to say that he didn't write about them. To appreciate his contribution, we must wait until Chapter 46, the chapter about dowsing.

"The Braes of Balquhidder" by the Scottish "Weaver Poet," Robert Tannahill (1774-1810), contemporary to Robert Burns, is the basis for the ballad "Wild Mountain Thyme," with its familiar chorus "Will Ye Go Lassie, Go."

Tannahill didn't write about underground rivers, but as he met his demise in one, we'll include him in our survey. As lamented 37 years after the fact in Northern Star, and National Trades' Journal, February 6 1847,

> *But still more melancholy is the contemplation of the beginning and the end of Robert Tannahill, the popular song writer of Paisley. Tannahill was no doubt stimulated by the fame of Burns. True, he had not the genius of Burns, but genius he had, and that is conspicuous in the many of those songs which during his lifetime were sung with enthusiasm by is countryman.*
>
> *Tannahill was a poor weaver of Paisley. The cottage where he lived is still to be seen, a very ordinary weaver's cottage in an ordinary street; and the place where he drowned himself may be seen too at the outside of the town. This is one of the most dismal places in which a poet ever terminated his career...*
>
> *Outside of Paisley there is a place where a small stream passes under a canal. To facilitate this passage, a deep pit is sunk, and a channel foe the water is made under the bottom of the canal. This pit is, I believe, eighteen feet deep. It is built round with stone, which is rounded off at its mouth, so that any one falling in cannot by any possibility get out, for there is nothing to lay hold of. Any one once he goes there might grasp and grasp in vain for an edge to seize upon. He would sink back and back till he was exhausted and sank for ever.*
>
> *No doubt Tannahill in moments of gloomy observation had noticed this. And at midnight he came, stripped off his cost, laid down his hat, and took the fatal plunge. No cry could reach human ear form the horrible abyss; no effort of the strongest swimmer could avail to sustain him. Soon worn out he must go down, and amid the black boiling torrent be borne through the subterranean channel onward with the stream.*
>
> *Thus died Robert Tannahill, and a more fearful termination was never put to a poetical career. The place is called Tannahill's Hole.*



Paisley map, c. 1865 showing both Tannahill's Bridge and Tannahill's Hole

Where our poet's body was found.

If underground rivers merit the attention of poets, our topic has proven to be worthy one..

CHAPTER 32

TO CROSS THE STYX

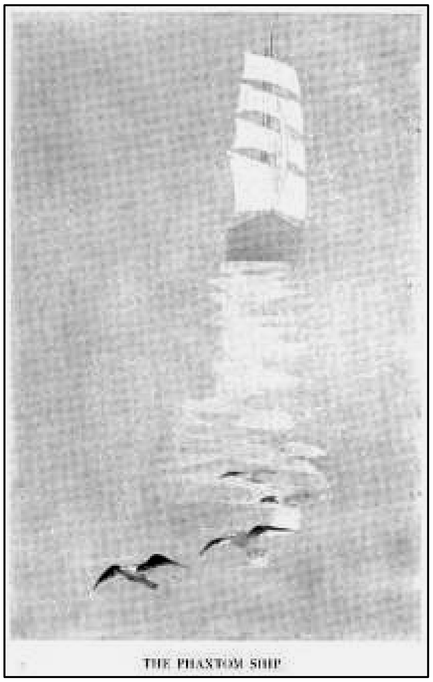
Water has numerous symbolic meanings. It is again and again divisible, yet when poured together, reconstitutes a seamless whole. It is life-giving, our first abode. We consume it daily. As a cleansing substance, we emerge from it purified.

Water can drown us, of course, but as myth is more often about the mortal soul than about physical safety, water is an agent of transformation of consciousness. In crossing the gulf between our world and that to follow, ego is dissolved, emerging completed and liberated on the distant shore.

The Greeks weren't arbitrary in myth creation when they made Charon a ferryman.

From Wander Ships: Folk-Stories of the Sea (1917) by Wilbur Bassett, the frontispiece at the right.

> *Many religions and cults look upon the sun as the abode of souls, and the sea the home of the sun into which it sinks at evening and disappears even as the soul after death. It is hidden or concealed. Hades is the unseen, the concealed place as is the Norse Hel (Icelandic helja, to hide). So we are not surprised to find that the Aryan words for sea, desert and death are from the same root. Thus we have in Anglo-Saxon mere, sea, lake; in Perian meru, desert; in Latin mors, death, from the same root as murder... And so in Egypt the sun set in the vast unexplored desert in the west. There was the land of Apap the immense, personification of the desert, the serpent king who guarded the approach to the halls of Osiris, the sun. Between this land and inhabitable Egypt lay the Nile, which was therefore the river of death. The death voyage and the ritual of the crossing of this river of death are clearly set out in the so-called Book of the Dead*

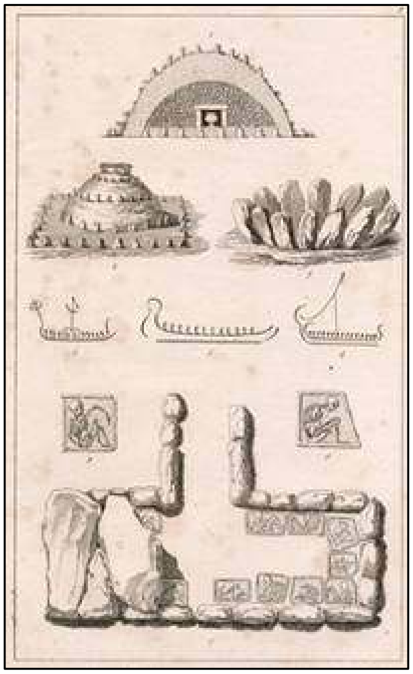


THE PHANTOM SHIP

> *The Midgard Sea of the Eddas was undoubtedly originally a river, as the sea is a conception not readily grasped by the primitive mind. That river was Jormungandr, which in the later mythology is described as the great Midgard worm, which lies at the bottom of the Midgard sea. So the Greek Oceanus, originally a river flowing in a circle like the Midgard serpent whose tail continued to grow into his mouth, disappeared in the ocean of later days.*
>
> *This leads to the general theorem that sea and ocean myths are less ancient than river myths, and indeed many sea-ceremonies of the present day hark back to that ever-flowing character characteristic of the primitive ocean.*

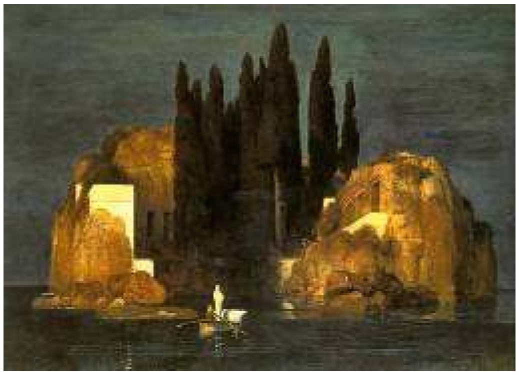
The Egyptian god of death, Osiris, was often symbolized by a boat.

Akin to the entombment of pharaohs and their retinues in elaborate barks for passage across the great divide, Norse tribes laid their leaders, along with grave offerings in accordance with earthly status, in a boat to bear them to Valhalla, Land of the Heroes.



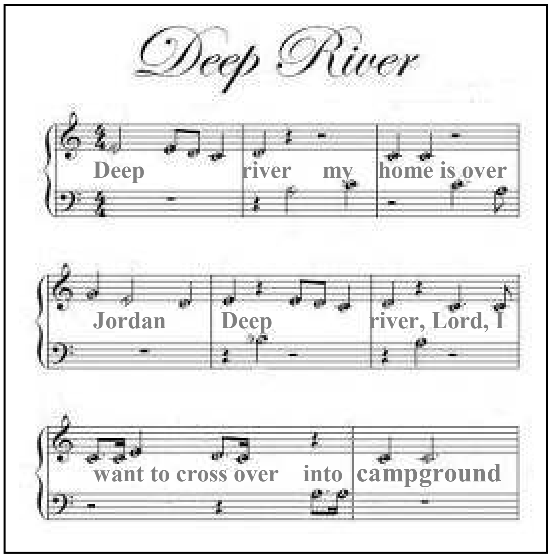
GLOBE
JOURNEY TO VALHALLA
JULY 4-5 BRUSSELS
WEVELGEM BELGIUM
JULY 6-7 AMSTERDAM NETHERLANDS
JULY 8-9 BERLIN GERMANY
JULY 11-12 OSLO NORWAY

Isle of the Dead (1880) by Arnold Böcklin.



Judeo-Christian tradition speaks of reaching the promised land by crossing the River Jordan. Isaiah 43.2 declares,

> *When thou passest through the waters, I will be with thee; and through the rivers, they shall not overflow thee.*


Deep River
Deep river my home is over
Jordan Deep river, Lord, I
want to cross over into campground

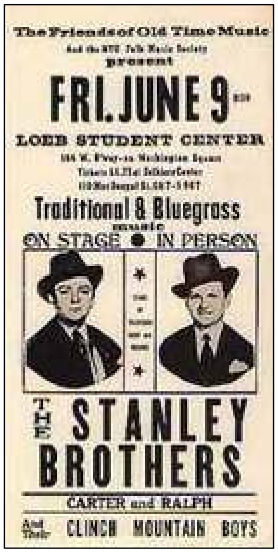
We could compile a lenghy list of crossing-the-river songs, but we'll mention just one more, "Standing by the River, Waiting for the Boatman" by the Syanley Brothers. As bluegrass muisic tends to avoid Greek references, Charon's not named, but we know the boatman.

Here I stand by this chilly water waitin' for my final call,
Standing by the river looking beyond.
Gazin' toward the land of fadeless beauty o'er the surges rise and fall,
Standing by the river looking beyond.

> *Standing by the river waiting for the boatman,*
> *Listen to the music on the other shore.*
> *I can hear the angels singing out a welcome*
> *With my friends and loved ones (with my friends have gone before).*

Music from the land of endless glory fallin upon my listening ear,
Standing by the river looking beyond.
Faces of my friends I often vision forms of loved ones oft appear,
Standing by the river looking beyond.

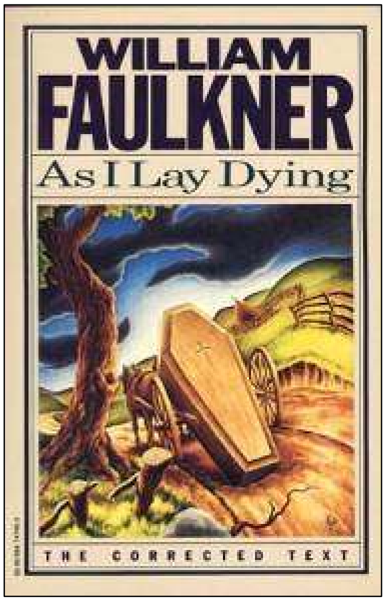
Shadows of night are swiftly falling lo I hear the boatman's oar,
Standing by the river looking beyond.
Many are the voices sweetly calling I must tarry hear no more,
Standing by the river looking beyond.



In modern literature, we can turn to Faulkner's As I Lay Dying (1964), a story of a river crossing between life and death. A line from the Odyssey, "As I lay dying, the woman with the dog's eyes would not close my eyes as I descended into Hades," inspired the title.

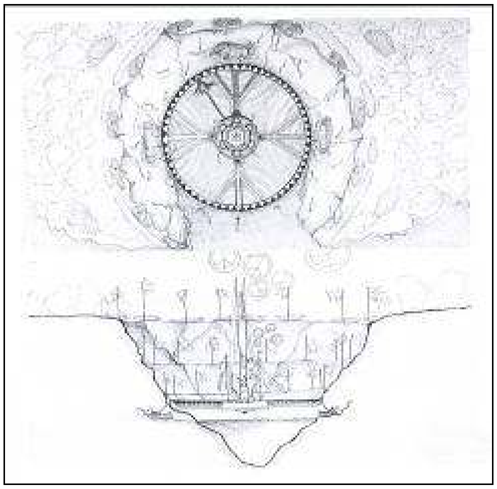
Before us the thick dark current runs. It talks up to us in a murmur become ceaseless and myriad, the yellow surface dimpled monstrously into fading swirls travelling along the surface for an instant, silent, impermanent and profoundly significant, as though just beneath the surface something huge and alive waked for a moment of lazy alertness out of and into light slumber again.'

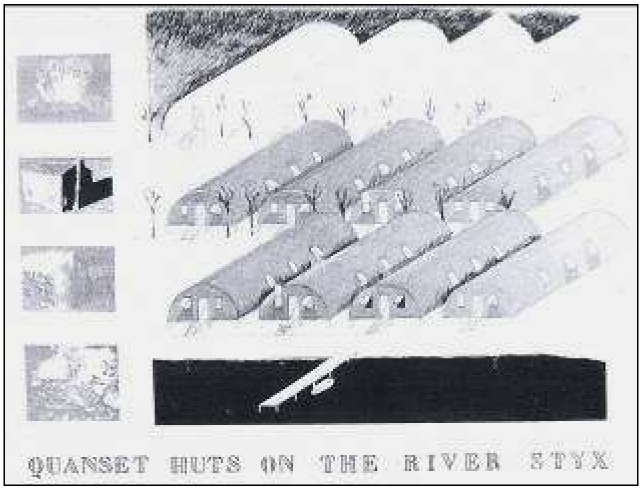
It clucks and murmurs among the spokes and about the mules' knees, yellow, skummed with flotsam and with thick soiled gouts of foam as though it had sweat, lathering, like a driven horse. Through the undergrowth it goes with a plaintive sound, a musing sound; in it the unwinded cane and saplings lean as before a little gale, swaying without reflections as though suspended on invisible wires from the branches overhead. Above the ceaseless surface they stand -- trees, cane, vines-rootless, severed from the earth, spectral above a scene of immense yet circumscribed desolation filled with the voice of the waste and mournful water.



Unfortunately for Faulkner's characters, they lacked a subterranean ferryman.

Or for those of us more into engineering, Quonset Huts on the River Styx, The Bomb Shelter Design Book (1993) is the product of a wry national competition by Architects/Designers/Planners for Social Responsibility for a "radiation-proof emergency operation center" for government officials. An entry is shown below, the conical depression harkening to Dante's circles of Chapter 6.




QUANSET HUTS ON THE RIVER STYX

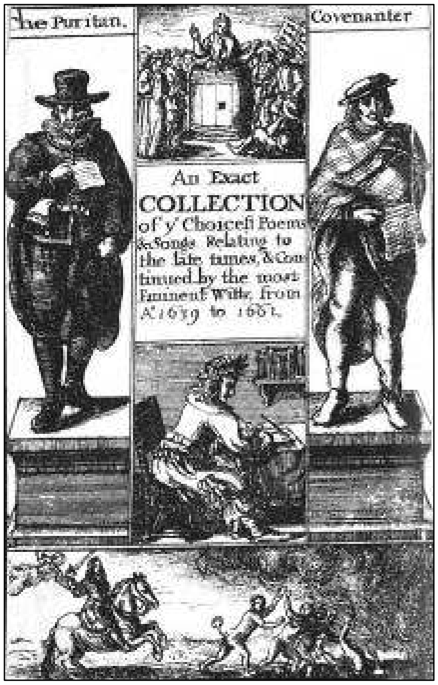
Crossing the Styx

A metaphoric figure of speech is a phrase literally designating one thing used for implicit comparison. "To cross the River Styx" as a metaphor for "to die" has been in English usage for hundreds of years. In a less-frequent sense, the phrase has also been employed to describe a sojourn to the underworld from which the protagonists returns.

The literature of crossing the Styx begins in the Aeneid where Aeneas, in search of his father, tries to cross the netherworld river. It was the Divine Comedy (1314) that propelled the metaphor into modern vocabulary, a somewhat inexplicable literary legacy because -- as we've noted In Chapters 1 and 6 -- Dante's river was the Acheron. We lack particulars regarding the actual crossing, unfortunately, as Dante had fainted, not to awaken until he was on the other side.

We've encountered "crossing the Styx" multiple times along our underground river journey, but we'll add a few less-morbid examples.

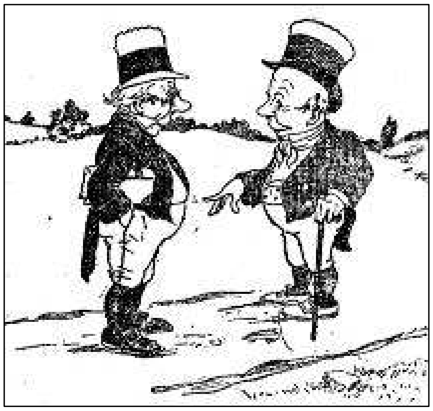
Let us begin in Jolly Old England. From Rump: or An Exact Collection of the Choycest Poems and Songs Relating to the Late Times by the Most Eminent Wits, from Anno 1639 to Anno 1661 (1662),


The Puritan.
Covenanter
An Exact
COLLECTION
of y' Choicest Poems & Songs Relating to the late times, & Continued by the most Eminent Witts, from A° 1639 to 1661.

A Boat for this Old Doctor
To cross the River Styx

For Pluto he
Desired to see
Some of his Antick tricks.

"Dead Ones," Salt Lake Telegram, March 5, 1903, attempts a bit of wordplay.

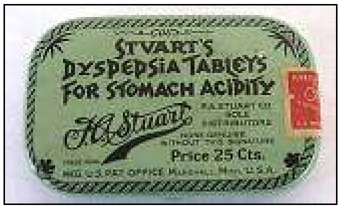


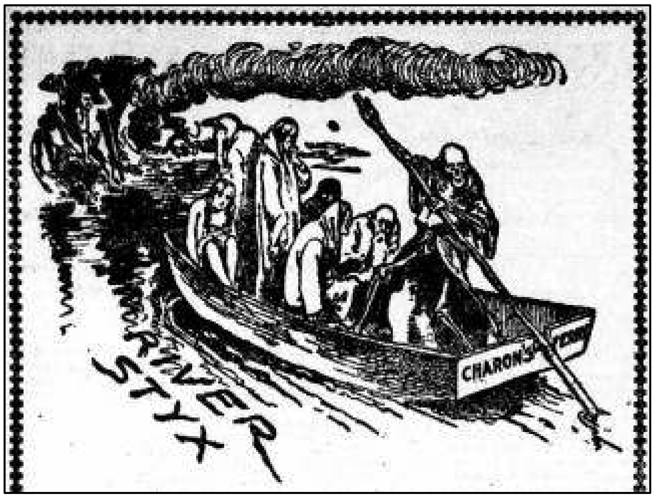
Blocks: *I'll warrant thee Charon did make a great deal of money out of his ferry across the river Styx.*

Stocks: *Nay, friend, were they not all deadheads?*

Crossing the Styx in marketing, as evidenced in an advertisement for Stuart's Dyspepsia Tablets in the Minneapolis Journal, January 27, 1912,

One does not have to cross the Styx
To reach the sultry nether;
Who's [sic] *liver and whose stomach mix*
Irascibly together





From the accompanying text,

> *The victim of dyspepsia is an abject slave to his stomach. He has to rigidly and continually deny his palate the gustatory relishes gastrointestinal turmoil, often amounting to severe suffering, follows his innocent and natural indulgence.*
>
> *If swallowing any reasonable quantity of properly cooked and well masticated food, such as others eat without discomfort, is followed by a feeling of heaviness, or a load, where it lies by gaseous distension or a bloated condition of the stomach, or oppression about the heart by watery, sour or windy risings by distress, nervousness, dizziness, nausea, headache. Inability to sleep rest fully or any other symptom of deficient, defective or disordered digestion you should procure and take Stuart's Dyspepsia Tablets, the best medicine to remedy all functional wrongs of the stomach.*
>
> *Stuart's Dyspepsia Tablets are for sale at all drug stores at 50 cents a box.*

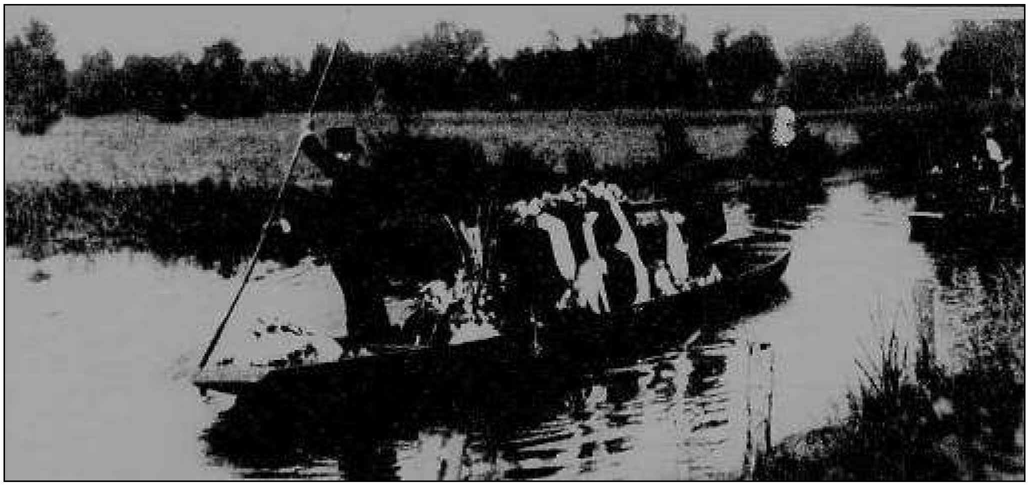
"Haskell's Account of the Battle of Gettysburg," The Harvard Classics (1909-1914), Charles W. Eliot, Ed., provides us a well-worded equestrian eulogy,

> *Dick deserves well of his country, and one day should have a horse-monument. If there be "ut sapientibus placit," and equine elysium, I will send to Charon the brass coin, the fee for Dick's passage over, and on the other side of the Styx in those shadowy clover-fields he may nibble blossoms forever.*

As a news item, "Prophets Initiate Fifty Candidates," Washington Times, May 20, 1914, reports,

> *Omitting the usual perils of the passage of the River Styx, more than 500 members of the Kallipolis Grotto, No. 15, Mystic Order of Veiled Prophets of the Enchanted Realm, met in the ballroom of the New Willard last night and initiated fifty candidates, had a real minstrel show and general jollification.*

"A Dress Rehearsal for the Styx," New York Tribune, October 31, 1920, finds a news item in the subject.

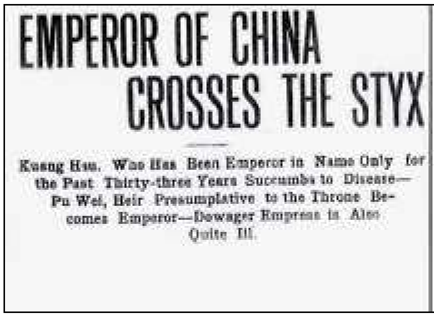


Since there are no streets in Spreewald, near Berlin, everything is transported after the fashion in vogue in Venice. When a native dies he is borne to his grave in a hearse-punt.

19-Avalon-57

The Mystic Order of Veiled Prophets of the Enchanted Realm is not an occult organization, we're glad to discover, but just a fellowship for Master Masons pursuing general jollification.

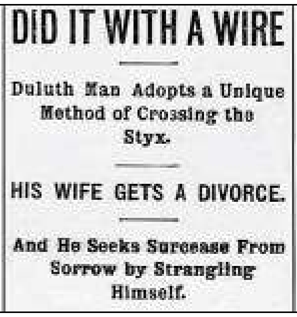
A few turn-of-the-century newspaper headlines:



EMPEROR OF CHINA CROSSES THE STYX

Kuang Hsu, Who Has Been Emperor in Name Only for the Past Thirty-three Years Succumbs to Disease—Pu Wei, Heir Presumplative to the Throne Becomes Emperor—Dowager Empress is Also Quite Ill.

Marion Daily Mirror, November 11, 1908



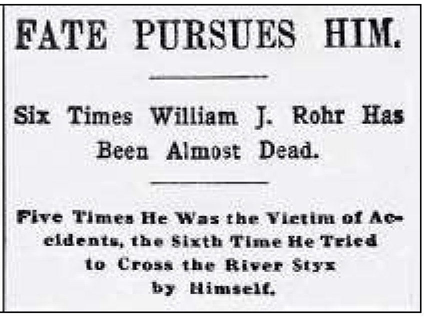
DID IT WITH A WIRE

Duluth Man Adopts a Unique Method of Crossing the Styx.

HIS WIFE GETS A DIVORCE.

And He Seeks Surcease From Sorrow by Strangling Himself.

St. Paul Daily Globe, April 11, 1895



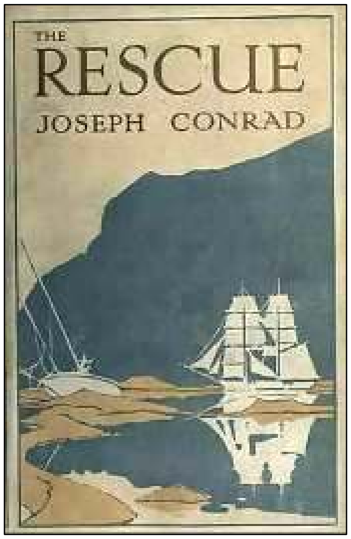
FATE PURSUES HIM.

Six Times William J. Rohr Has Been Almost Dead.

Five Times He Was the Victim of Accidents, the Sixth Time He Tried to Cross the River Styx by Himself.

Washington Bee, June 14, 1902

For an example in modern literature, we'll cite The Rescue: A Romance of the Shallows (1920) by Joseph Conrad.

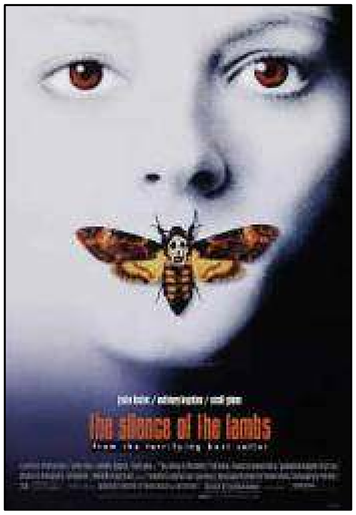


> *"I have a most extraordinary feeling," he* [the novel's insufferable narcissist yacht owner Mr. Travers] *said in a cautious undertone. "I seem to be in the air -- I don't know. Are we on the water, d'Alcacer?... Are you quite sure? But of course, we are on the water."*
>
> *"Yes," said d'Alcacer, in the same tone. "Crossing the Styx -- perhaps."*

We're thus forewarned.

Conrad's Lord Jim (1900) contains "as black as Styx," another oft-used metaphor. Heart of Darkness (1899) is set on about a dark river, but one entirely above ground.

The allusion to fatality, we find, extends even to science, per the Acherontia styx, the Death's Head hawkmoth, made famous in the film Silence of the Lambs (1991).


the silence of the lambs
from the terrifying best seller

A Metaphoric Stygian Library

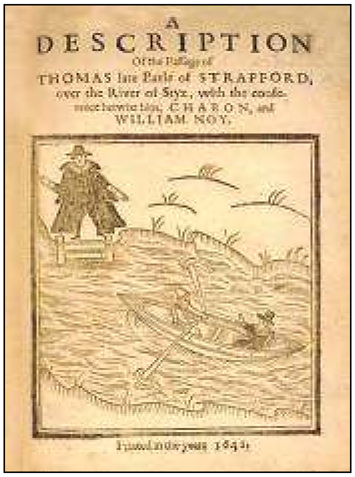
Let us draw together books in English having titles employing a Stygian allusion. To maintain a degree of propriety, however, we'll omit titles dealing with

1. Comic books set the underworld, a subject of Chapter 24, and
2. The rock band mentioned in Chapter 36.

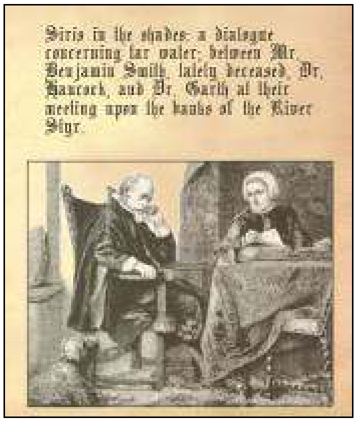
The commonality of our collection stems from the word "Styx" in the title, the proclamation that what follows is about death.

We'll begin our book collection with a pair of pamphlets.

An imagined meeting between notable personalities at death's doorstep provided commentators of centuries past a wry forum in which to examine the day's issues.

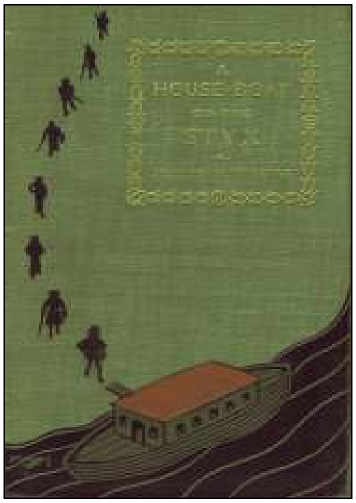

A
DESCRIPTION
THOMAS late Earle of STRAFFORD,
over the River of Styx, with the confe-
rence betwixt him, CHARON, and
WILLIAM NOY.

A Description of the Passage of Thomas Late Earle of Strafford over the River of Styx, with the Conference Betwixt Him, Charon, and William Noy (1641)

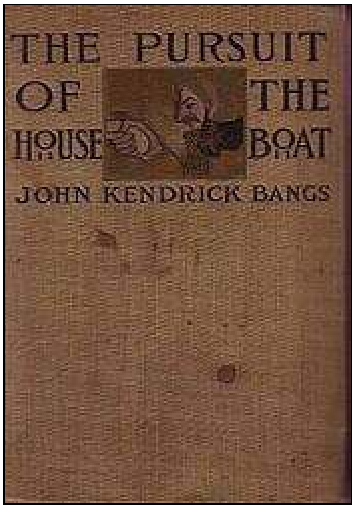

Siris in the shades: a dialogue concerning tar water: between Mr. Benjamin Smith, lately deceased, Dr. Hancock, and Dr. Garth at their meeting upon the banks of the River Styx.

Siris in the Shades : A Dialogue Concerning Tar Water; between Mr. Benjamin Smith, Lately Deceased, Dr. Hancock, and Dr. Garth, at Their Meeting upon the Banks of the River Styx (1744)

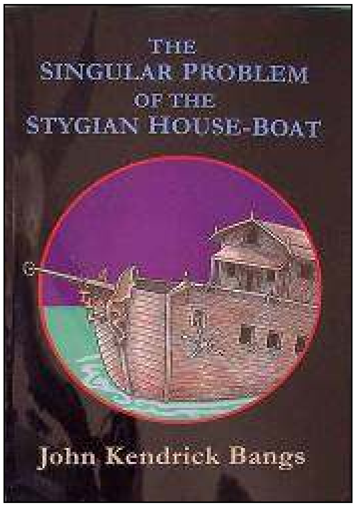
We'll add two works by John Kendrick Bangs about the denizens of Hades, plus the compilation of the two.


A HOUSE-BOAT ON THE STYX

John Kendrick Bangs, A House-Boat on the Styx (1895)


THE PURSUIT OF THE HOUSE BOAT
JOHN KENDRICK BANGS

Pursuit of the Houseboat (1897)


THE SINGULAR PROBLEM OF THE STYGIAN HOUSE-BOAT
John Kendrick Bangs

The Singular Problem of the Stygian House-Boat,

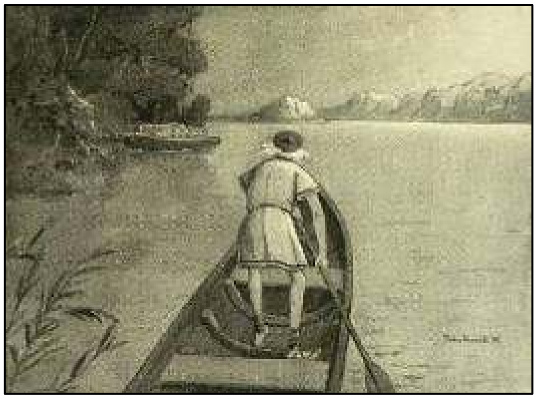
From A House-Boat on the Styx, we quote from "Charon Makes a Discovery."

> *Charon, the Ferryman of renown, was cruising slowly along the Styx one pleasant Friday morning not long ago, and as he paddled idly on he chuckled mildly to himself as he thought of the monopoly in ferriage which in the course of years he had managed to build up.*
>
> *"It's a great thing," he said, with a smirk of satisfaction--"it's a great thing to be the go-between between two states of being; to have the exclusive franchise to export and import shades from one state to the other, and withal to have had as clean a record as mine has been. Valuable as is my franchise, I never corrupted a public official in my life, and --"*

> *Here Charon stopped his soliloquy and his boat simultaneously. As he rounded one of the many turns in the river a singular object met his gaze, and one, too, that filled him with misgiving. It was another craft, and that was a thing not to be tolerated. Had he, Charon, owned the exclusive right of way on the Styx all these years to have it disputed here in the closing decade of the Nineteenth Century?*

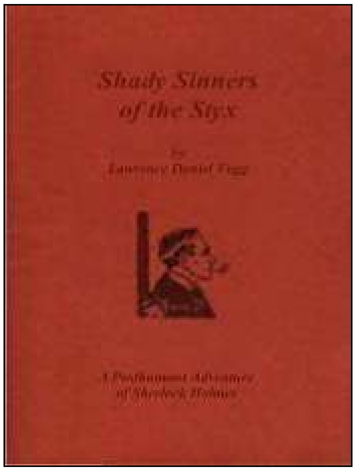
The ferryman fears the arrival of a houseboat, one bearing everyone that's ever died, will put him out of business, but finds out that he's actually to be appointed the boat's janitor.

What follow are stories set on the houseboat, what might transpire if departed notables were put in the same room. We meet Sir Walter Raleigh, Cassius, Demosthenes, Blackstone, Confucius, Shakespeare, Washington, Baron Munchausen, Confucius, Napoleon, Diogenes, Ptolemy, Boswell, Columbus, Cicero, Henry VIII, Doctor Johnson, Doctor Livingstone, Samson, Darwin, Mozart, Tennyson, Thackeray, Burns, Homer, Carlyle, Noah, Adam, P.T. Barnum, Queen Elizabeth and Ophelia!

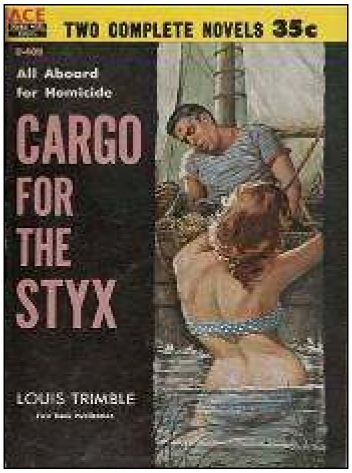


The Odyssean Charon, however, had no such erudite sailing, as evidenced by the spirit's astonishment that Odysseus could have crossed to Hades from the land of the living. “For in between lie the great rivers and terrible waters that flow, Ocean first of all.” What Bangs got right was the fact that the houseboat passengers were all quite deceased.

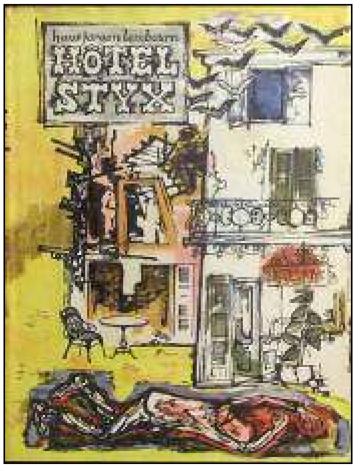
As we haven't the space to quote from the rest of our Stygian library, we'll just show the covers.


Shady Sinners of the Styx
by
Lawrence Daniel Fogg
A Posthumous Adventure of Sherlock Holmes

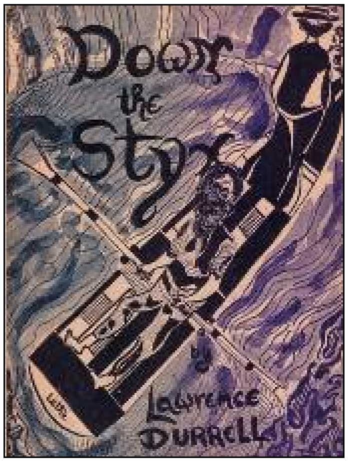
Lawrence Daniel Fogg, Shady Sinners of the Styx (1906)


ACE
TWO COMPLETE NOVELS 35c
All Aboard for Homicide
CARGO FOR THE STYX
LOUIS TRIMBLE

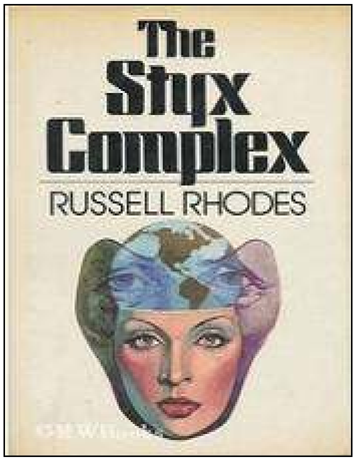
Louis Trimble, Cargo for the Styx (1961)


hans jørgen lembourn
HOTEL STYX

Hans Jorgen Lembourn, Hotel Styx (1964)


Down the Styx
Lawrence Durrell

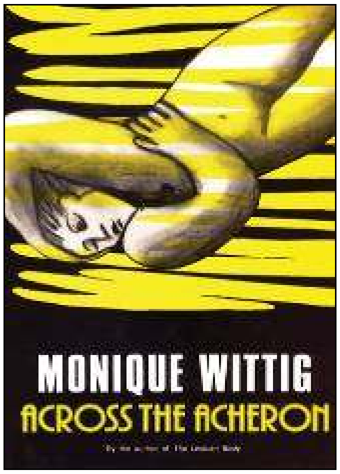
Lawrence Durrell, Down the Styx (1971)


The Styx Complex
RUSSELL RHODES

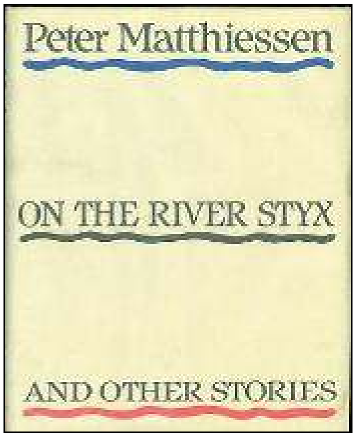
Russell Rhodes, The Styx Complex (1977)

THEODORE STURGEON
The Stars Are the Styx

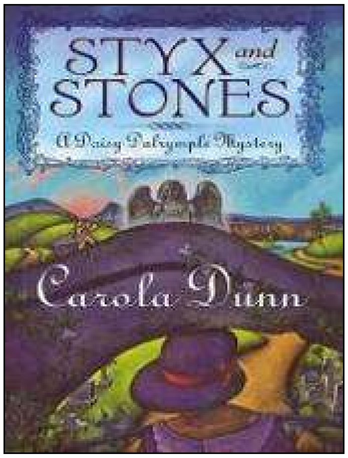
Theodore Sturgeon, The Stars Are the Styx (1979)


MONIQUE WITTIG
ACROSS THE ACHERON

Monique Wittig, Across the Acheron (1987)


Peter Matthiessen
ON THE RIVER STYX
AND OTHER STORIES

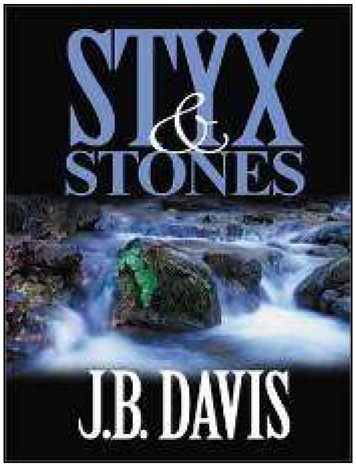
Peter Matthiessen, On the River Styx and Other Stories (1989)


STYX and STONES
A Daisy Dalrymple Mystery
Carola Dunn

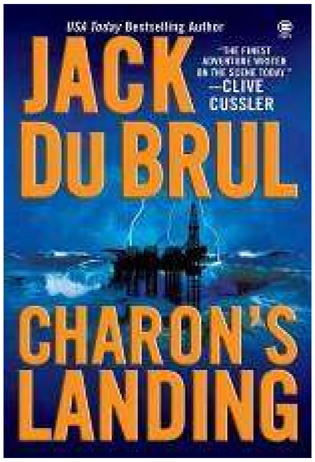
Carola Dunn, Styx and Stones (1999)

ANDREAS FOERSTER
STYX

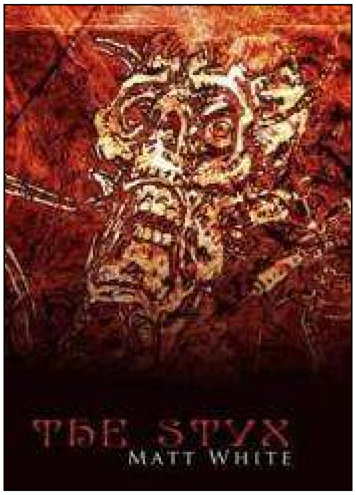
Andreas Foerster, Styx (2001)


STYX & STONES
J.B. DAVIS

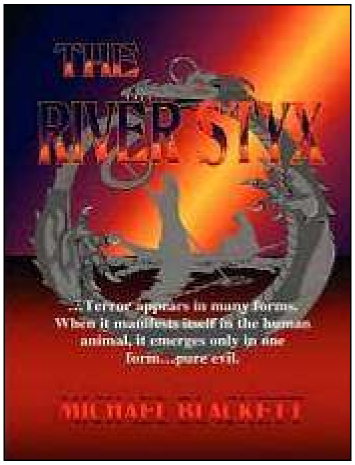
J.B. Davis, Styx and Stones (2001)


USA Today Bestselling Author
JACK DU BRUL
"THE FINEST ADVENTURE WRITER ON THE SCENE TODAY." —CLIVE CUSSLER
CHARON'S LANDING

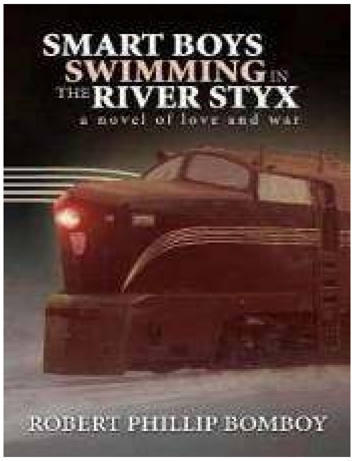
Jack Du Brul, Charon's Landing (2001)


THE STYX
MATT WHITE

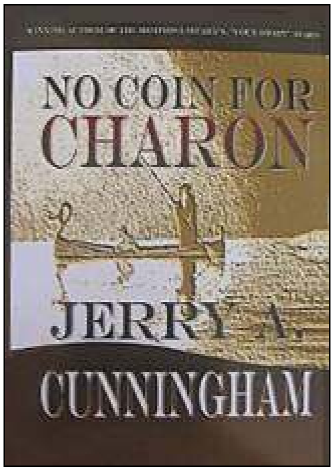
Matt White, The Styx (2006)


THE RIVER STYX
...Terror appears in many forms. When it manifests itself in the human animal, it emerges only in one form...pure evil.
MICHAEL BLACKETT

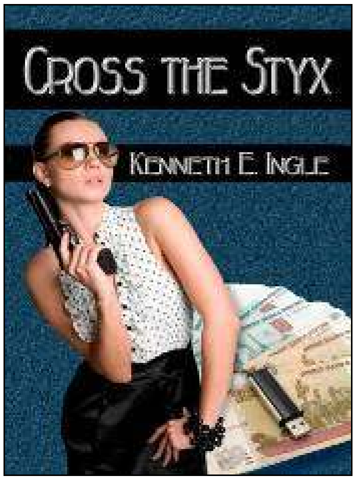
Michael Blackett, The River Styx (2006)


SMART BOYS SWIMMING IN THE RIVER STYX
a novel of love and war
ROBERT PHILLIP BOMBOY

Robert Bomboy, Smart Boys Swimming in the River Styx (2007)


NO COIN FOR CHARON
JERRY A. CUNNINGHAM

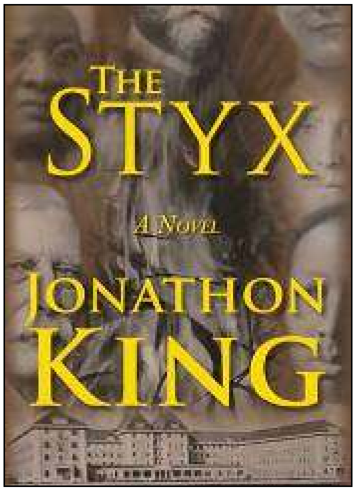
Jerry Cunningham, No Coin For Charon (2008)


CROSS THE STYX
KENNETH E. INGLE

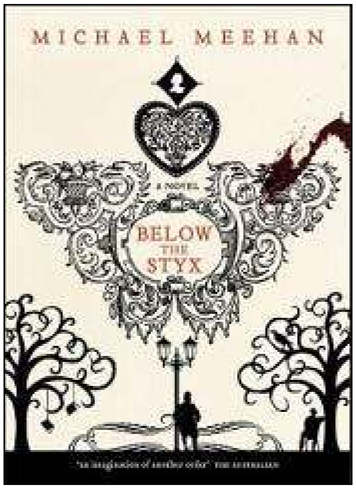
Kenneth Ingle, Cross the Styx (2010)

Ian R. MacLeod: Recrossing the Styx
Fantasy & Science Fiction
JULY/AUG
The Precedent
Sean McMullen
Richard Bowes
Albert E. Cowdrey
John Langan

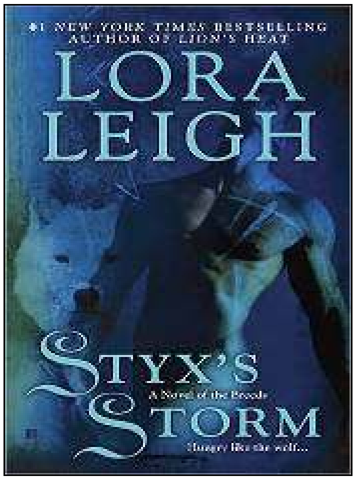
Ian R. MacLeod, "Recrossing the Styx," Fantasy & Science Fiction, July-August 2010


THE STYX
A NOVEL
JONATHON KING

Jonathan King, The Styx (2010)

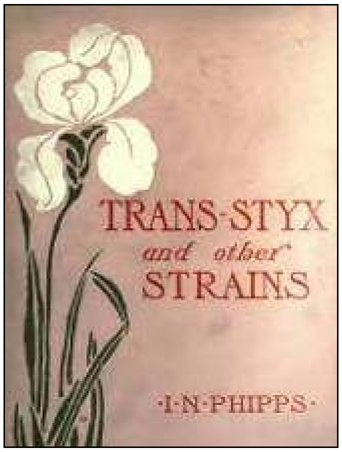

MICHAEL MEEHAN
A NOVEL
BELOW THE STYX

Michael Meehan, Below the Styx (2010)

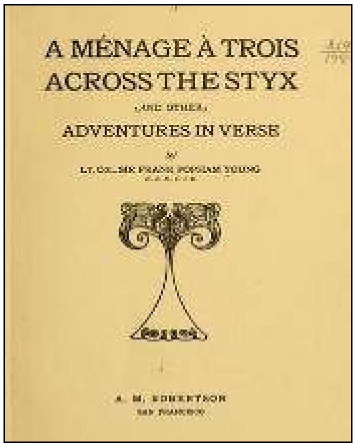

#1 NEW YORK TIMES BESTSELLING AUTHOR OF LION'S HEAT
LORA LEIGH
STYX'S STORM
A Novel of the Breeds
Hungry like the wolf...

Lora Leigh, Styx's Storm (2010)

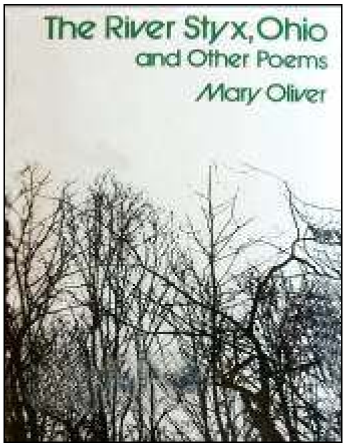
Poetry speaks for itself.


TRANS-STYX
and other
STRAINS
·I·N·PHIPPS·

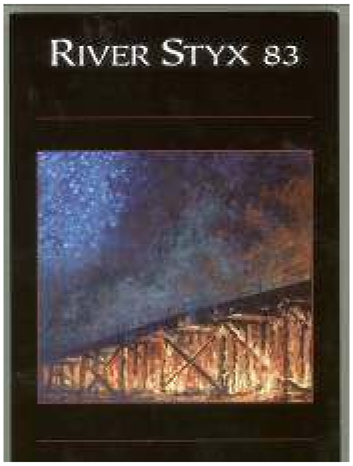
Isaac Newton Phipps, Trans-Styx and Other Strains (1907)


A MÉNAGE À TROIS
ACROSS THE STYX
(AND OTHER)
ADVENTURES IN VERSE
A. M. ROBERTSON
SAN FRANCISCO

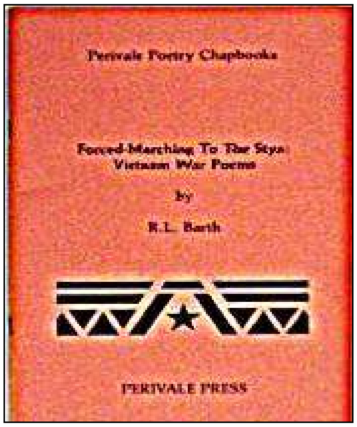
Frank Popham Young, Across the Styx and Other Adventures in Verse (1922)


The River Styx, Ohio
and Other Poems
Mary Oliver

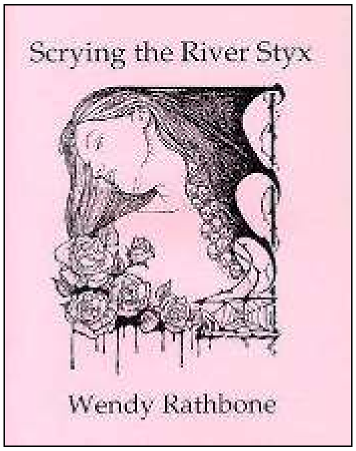
Mary Oliver, The River Styx, Ohio, and Other Poems (1972)


RIVER STYX 83

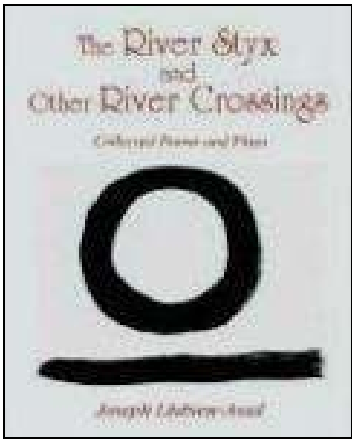
River Styx magazine, since 1975


Perivale Poetry Chapbooks
Forced-Marching To The Styx: Vietnam War Poems
by
R.L. Barth
PERIVALE PRESS

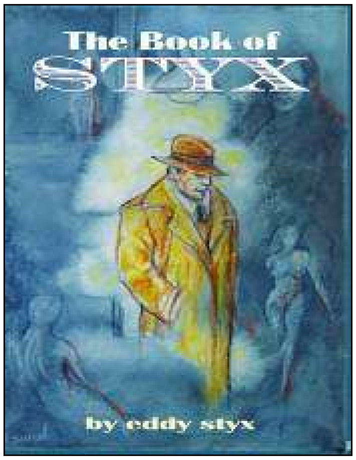
R.L. Barth, Forced-Marching to the Styx, Vietnam War Poems (1983)


Scrying the River Styx
Wendy Rathbone

Wendy Rathbone, Scrying the River Styx (1999)


The River Styx and Other River Crossings
Collected Poems and Plays
Joseph Llubien-Asad

Joseph Llubien-Asad , The River Styx and Other River Crossings (2003)


The Book of STYX
by eddy styx

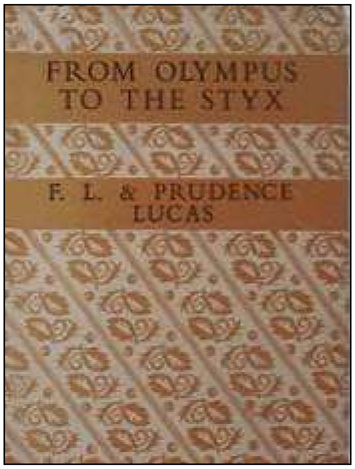
C.M. Mattison, a.k.a. Eddy Styx, The Book of Styx (2009)

And as poetry requires special handling, we'll quote a few poets whose works aren't in bound volumes with "Styx" on the cover.

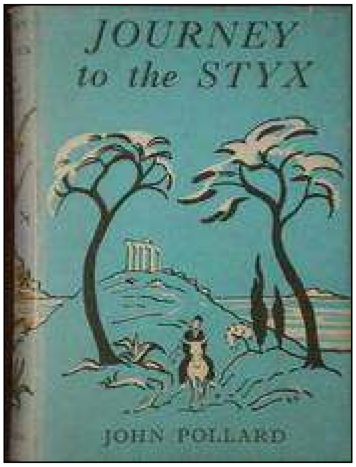
"The Little Shade," Greek Wayfarers (1916) by Edwina Stanton Babcock	"On a Picture" by Jean Ingelow
No longer that gray visage fix, *Charon,* *Asking me bow I come to mix* *With this pale boat-load on the Styx,* *Charon.*	*As a forlorn soul waiting by the Styx* *Dimly expectant of lands yet more dim,* *Might peer afraid where shadows change and mix* *Till the dark ferryman shall come for him.*

I am so very small a Shade, *Charon,* *Holding the vase my father made* *And toys of silver all inlaid,* *Charon.* *Ferry me to the golden trees,* *Charon,* *To isles of childish play and ease* *And baths of dove-like Pleiades.* *Charon.* *Ferry me to the azure lands ,* *Charon,* *Where some dead mother understands* *The lifting of my baby hands,* *Charon.*	"Photograph of My Mother on the River Styx" (2008) by Jeanne K Wagner *How still she looks, among strangers, with* *only the lingua franca of silence* *between them, while she waits for* *the boat to dock, for Charon* *to take her by tip of the elbow* *and steady her as she disembarks.*

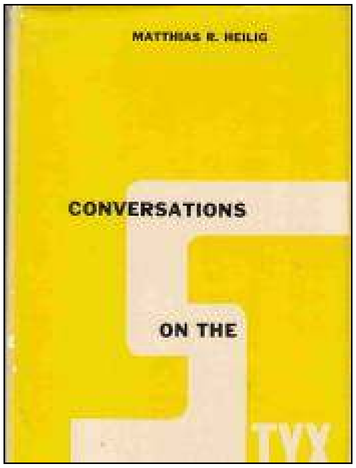
Our nonfiction volumes,


FROM OLYMPUS TO THE STYX
F. L. & PRUDENCE LUCAS

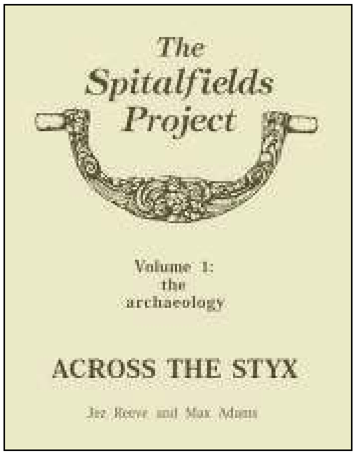
F.L. Lucas, From Olympus to the Styx (1934), Travelogue


JOURNEY to the STYX
JOHN POLLARD

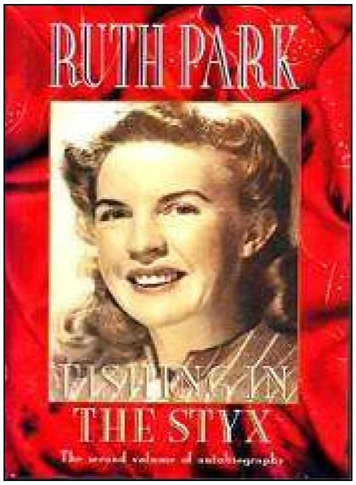
John Pollard, Journey to the Styx (1955), Essays


MATTHIAS R. HEILIG
CONVERSATIONS
ON THE
TYX

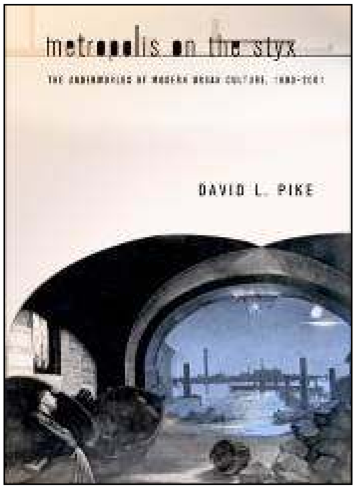
Matthias Heilig, Conversations on the Styx (1967), Philosophy


The Spitalfields Project
Volume 1: the archaeology
ACROSS THE STYX
Jez Reeve and Max Adams

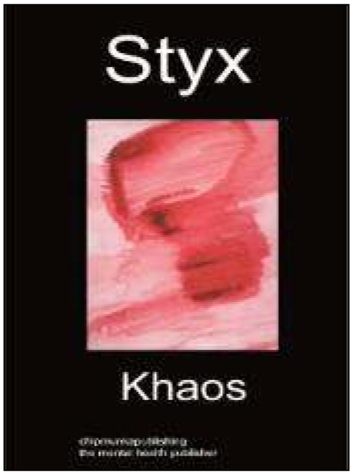
Jez Reeve and Max Adams, Across the Styx (1993), Archeology


RUTH PARK
FISHING IN THE STYX
The second volume of autobiography

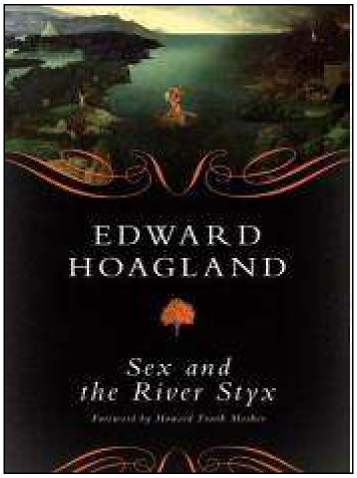
Ruth Park, Fishing in the Styx (2000), Biography


metropolis on the styx
The Underworlds of Modern Urban Culture, 1800-2001
DAVID L. PIKE

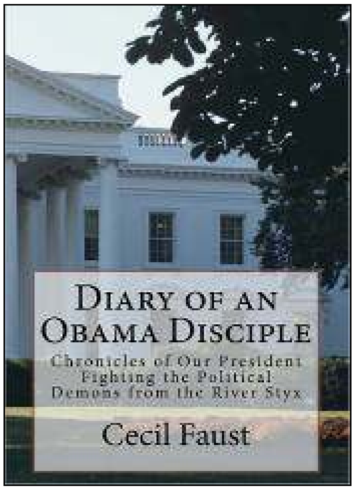
David Pike, Metropolis on the Styx (2007), Mythology


Styx
Khaos
chipmunkapublishing
the mental health publisher

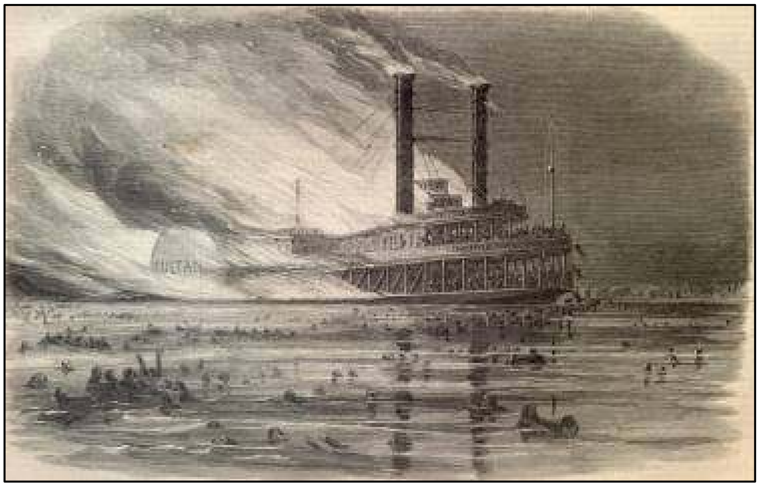
Khaos, Styx (2011), Mental Illness


EDWARD HOAGLAND
Sex and the River Styx
Foreword by Howard Frank Mosher

Edward Hoagland, Sex and the River Styx (2011), Essays


DIARY OF AN OBAMA DISCIPLE
Chronicles of Our President Fighting the Political Demons from the River Styx
Cecil Faust

Cecil Faust, Diary of an Obama Disciple Chronicles of Our President Fighting the Political Demons from the River Styx (2011), Politics

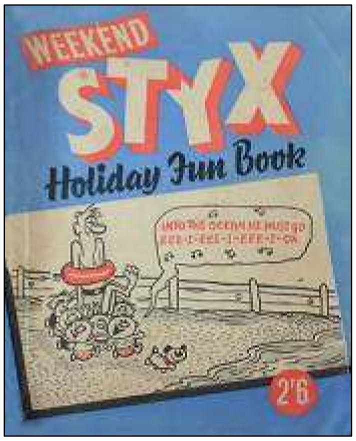


The April 27, 1865, explosion of the Mississippi paddle-wheeler SS Sultana was the greatest maritime disaster in American history. An estimated 1,800 passengers, most of them liberated Union prisoners, were killed when the ship's four boilers exploded near Memphis.

An illustration from Harper's Weekly, May 20, 1865.

A few lines from the "Sultana" by Jon Waterman.

> *Fifteen hundred men were drowned or scalded by the steam*
> *And ferried off to a different home then the ones of which they dreamed*
> *See how greed can turn a man like a gambler turns his tricks*
> *Or even make the mighty Mississippi into the River Styx.*



Our collection's final volume, Styx Holiday Fun Book (1958) by Leslie Harding, at first seems miscataloged. What can be fun about Styx?

Styx, we discover, is the author. According to Adrian Room, compiler of Dictionary of Pseudonyms (2010),

> *The artist began his career drawing sporting strips. Hence presumably his name, alluding both to the river crossed by the souls of the dead in classical mythology and the "sticks" or fences that horsed jump in a steeplechase*

Room's presumption may be correct, of course, but we find it unconvincing. Rather, we see a darker pseudonymic mantle in the Fun Book's cover cartoon, a helpless chap being borne by urchins into the water,

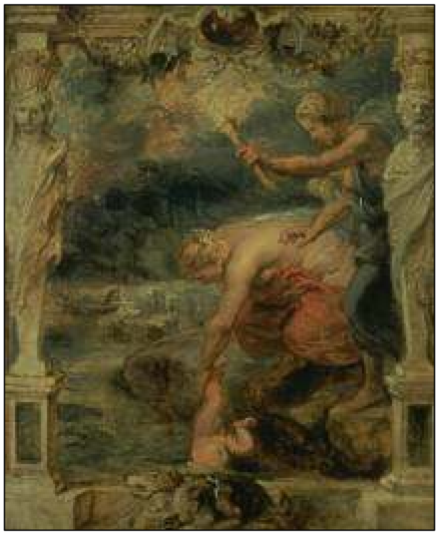
Will, we might ask after dusting our bookshelf, the metaphorical "crossing the Styx" succumb to its self definition and fade from popular parlance?

Our collection's ever-increasing count suggests that the metaphor itself is crossing no such river.

We'll end our chapter with two small digressions: one, a classical metaphor involving the Styx, but not mentioning our river by name, the other, a contemporary short story about the crossing.

Achilles' Heel

An Achilles' heel is a weakness in spite of overall strength. While its genesis refers to physical vulnerability, it can be metaphorically employed for other attributes or qualities that can likewise lead to downfall.



In Greek mythology, when Achilles was an infant, it was foretold that he would die in battle from an arrow in the foot. To prevent the outcome, his mother Thetis dipped his body into the River Styx, waters with the power of invincibility.

But as we can see in Rubens' "Thetis Dips Achilles in the Styx" (c. 1630), Thetis dangled her son by his foot and his heel was not immersed. Achilles grew to survive great battles, but one day a poisoned arrow lodged in his heel and killed him.

Legend begets legend, of course. Alexander the Great (356-323 BC and Aristotle's student) is said to have met his demise by drinking water from the Styx sent to him in a mule's hoof. There may, however, be an element of truth in the story. As reported some three millennia later in "Alexander the Great Killed by Toxic Bacteria?" Discovery News, July 16, 2010,

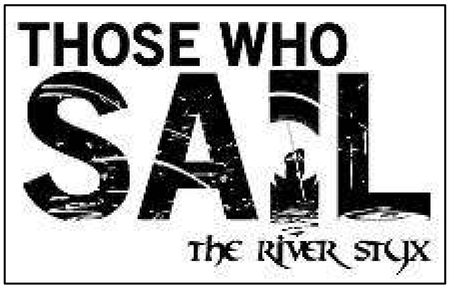
> *The Styx River, the legendary portal to the underworld, harbors a deadly bacteria that may have ended Alexander's life.*
>
> *An extraordinarily toxic bacterium harbored by the "infernal" Styx River might have been the fabled poison rumored to have killed Alexander the Great (356-323 BC) more than 2,000 years ago, according to a scientific-meets-mythic detective study.*
>
> *The research, which will be presented next week at the XII International Congress of Toxicology annual meetings in Barcelona, Spain, reviews ancient literary evidence on the Styx poison in light of modern geology and toxicology.*
>
> *According to the study, calicheamicin, a secondary metabolite of Micromonospora echinospora, is what gave the river its toxic reputation.*
>
> *Pausanias (110-180) reported that the river could ruin crystal, pottery and bronze. "(The) only thing able to resist corrosion is the hoof of a mule or horse," he wrote.*
>
> *"Indeed, no ancient writer ever casts doubt on the existence of a deadly poison from the Styx River," Mayor, author of the Mithradates biography The Poison King, said.*
>
> *The researchers believe this mythic poison must be calicheamicin. "This is an extremely toxic, gram-positive soil bacterium and has only recently come to the attention of modern science. It was discovered in the 1980s in caliche, crusty deposits of calcium carbonate that form on limestone and is common in Greece," author Antoinette Hayes, toxicologist at Pfizer Research, told Discovery News.*
>
> *Alexander fell ill at one of many all-night drinking parties in Babylon, in modern Iraq, crying out from a "sudden, sword-stabbing agony in the liver." The overlord of an empire stretching from Greece to India was taken to bed with abdominal pain and a very high fever.*
>
> *Over the next 12 days, he worsened. Alexander could only move his eyes and hands and was unable to speak. He later fell into a coma.*
>
> *Alexander was pronounced dead on June 11, 323 BC -- just before his 33rd birthday.*

> *"Notably, some of Alexander's symptoms and course of illness seem to match ancient Greek myths associated with the Styx. He even lost his voice, like the gods who fell into a coma-like state after drinking from the river.*

We'll return to the Oath of the Styx in Chapter 63, the Law of Subterranean Streams, and to water quality in Chapter 75, Mainlining the Sewage.

Those Who Sail

A 2012 short story by Trevor Faulkner, "Those Who Sail the River Styx," adds a human twist to Charon and the crossing. We'll extract a few lines about our weary boatman that don't reveal the story's conclusion.



> *The thin, bearded man pulled his robe's gray hood over his wrinkled face. His centuries of ferrying souls across the river Styx had taught him that the effect garnered by this appearance was one of the most important parts of his job. Most people would expect nothing less than the hooded boatman, and he would hate to ruin someone's death. He leaned into the current and steered for the rickety dock where three men now stood.*

> *Those who sail the river Styx, who wait upon the shore. Confronted with the boatman's cry might cower before their fall. And those who would escape their fate only hear these words. There's only one way back to land, my boy, and no one knows it but the boatman.*

CHAPTER 33

TWENTY-FIVE CENTURIES OF SUBTERRANEAN PORTRAITS

We'd be deficient in our underground river journey, were we not to salute the curmudgeon Charon, who navigates the River Styx. But as the chapter just completed -- the one about the river -- was substantially literary, we'll make this chapter one of pictures, a scrapbook.

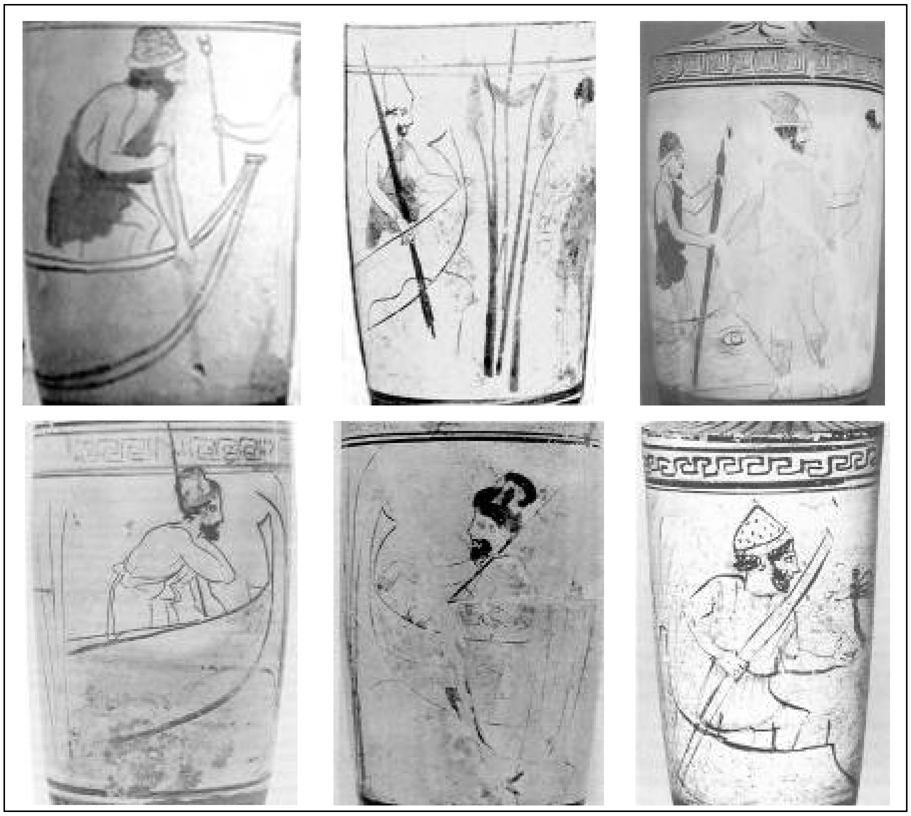
Here, then, is a pictorial chronology of Charon's portrayal over twenty-five centuries of labor. In our portrait gallery, we will observe,

1. That the portrayal of the aged mariner has evolved,
2. That the catalog of illuminations, woodcuts and engravings far exceeds the count of watercolors and oils, thanks to centuries of illustrated editions of the Divine Comedy, and
3. That the Masters ignored the fact that their subject labors in darkness. A painting requires light.

Fifth Century BC

White slip lekythos pottery was used for Grecian funeral rites between 470 and 400 BC. Figures were outlined in red or black matte and filled in with purple, brown, red yellow, rose, vermilion and sky blue. In nearly all recovered artifacts, however, those colors have long since faded, so black and white photography is sufficient to depict what remains.

Given his duty, a picture of Charon was a common funerary adornment.



Noting the orthodoxy in Charon's representation as a robust Athenian seaman, we might wonder if bereaved families, striving for the departed's most favorable fate, thought it prudent to flatter the oarsman?

Other information relating this era comes from Pausanias (Chapter 3) who wrote that the Lesche in Delphi once contained paintings by the fifth century BC Greek painter Polygnotus, and in one of these pieces,

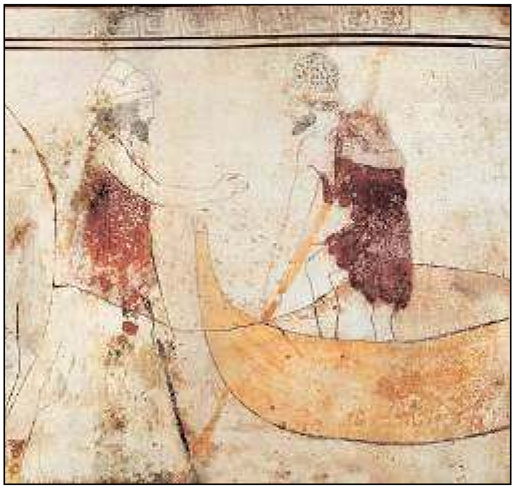
> *There is water to indicate a river, no doubt the Acheron... On the river there is a boat and the ferryman at the oars. Polygnotus, I think, follows the poem called the Minyad, for in this poem there is a passage about Theseus and Pirithous, "Then the bark of the dead which the old ferryman, Charon, was wont to guide, they found not at its moorings."*

We thus have disparate ages for our ferryman:

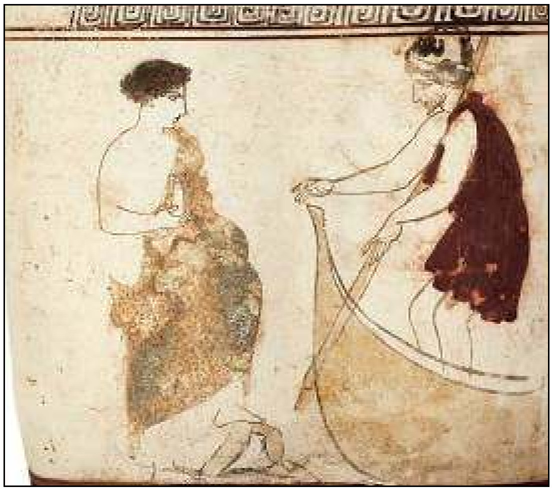
From period ceramics, an oarsman in his prime, or
According to a Roman speculating on a work lost centuries earlier, an "old ferryman."

As we move forward through art history, we'll see many contradictions and changes in the characteristics of our subject.

A pair of circa-430 BC representations

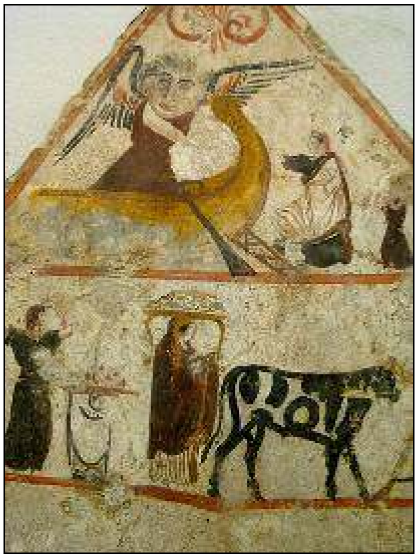


Hermes Psychopompos and Charon

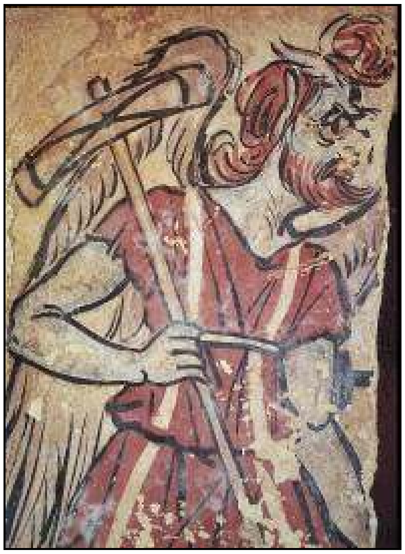


Charon trying to persuade a woman to board

Third and Fourth Centuries BC



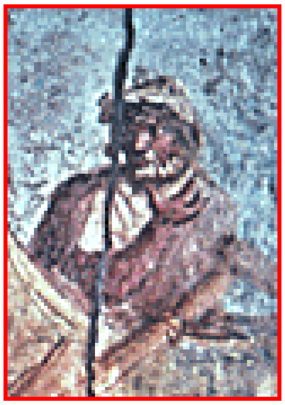
The Lucanian tomb painting (350-320 BC) shows Charon welcoming a deceased woman. Like what Christians would later call angels, this Charon is indeed winged.

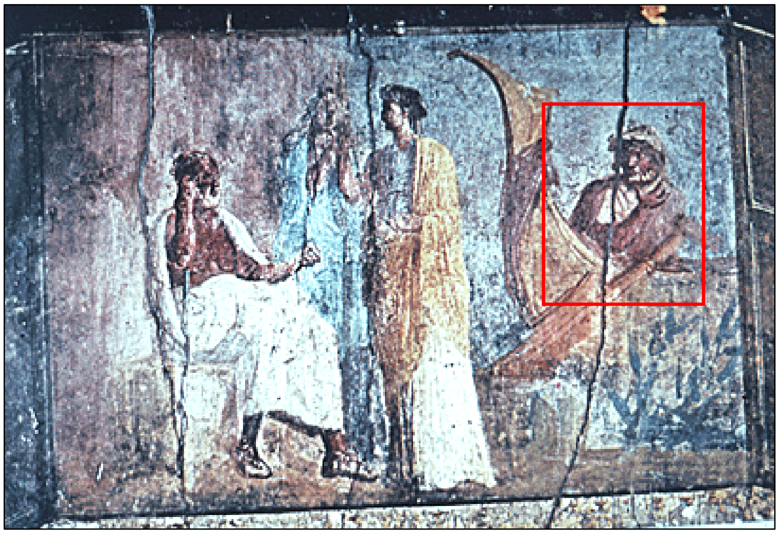


As depicted on the Etrurian tomb entry (c. 200 BC), Charon shows personality. Affixed to his back are, yes, again wings.

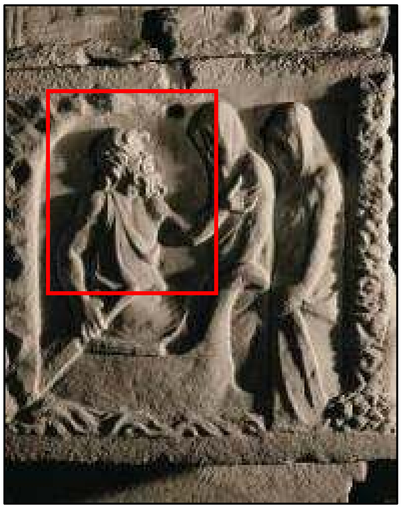
First Century AD

A Pompeii wall painting of Admetus, Alcestis and a Romanized Charon.





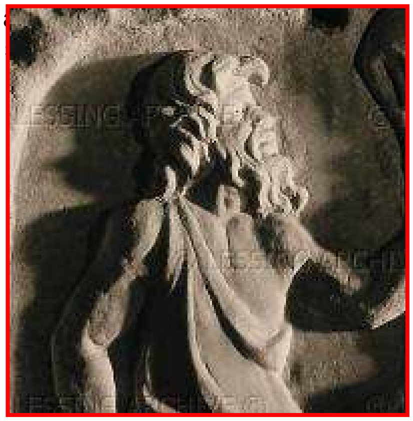
Third Century



The Roman sarcophagus portrays a Charon with locks less kept and physique more gaunt, a Charon more akin to the aged boatman of Virgil's Aeneid, which would by now have been recited for 200 years.

> *There Charon stands, who rules the dreary coast --*
> *A sordid god, down from his hairy chin*
> *A length of beard descends, uncombed, unclean;*
> *His eyes, like hollow furnaces on fire;*
> *A girdle, foul with grease, binds his obscene attire.*

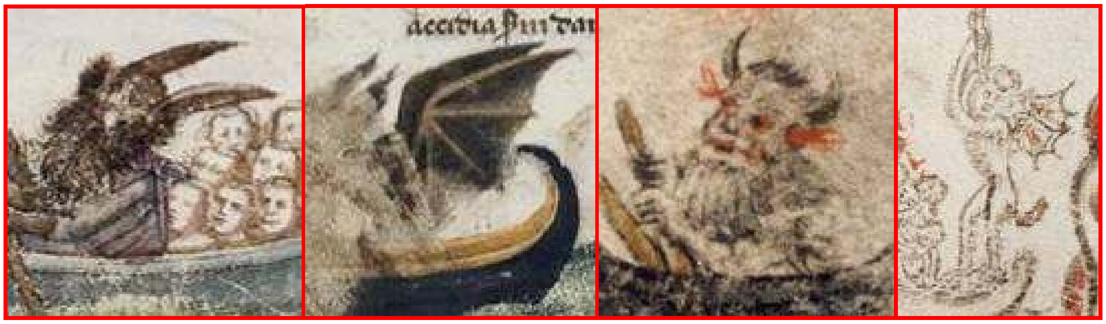
Virgil may have portrayed
effect, or perhaps the oral
reached even his ears.

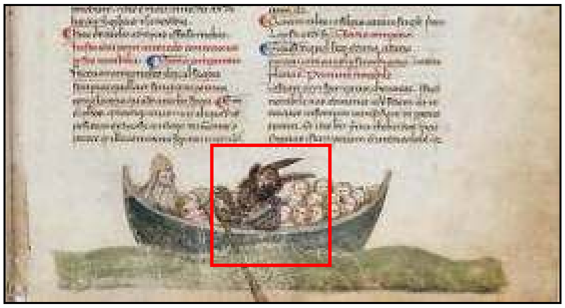


14th Century

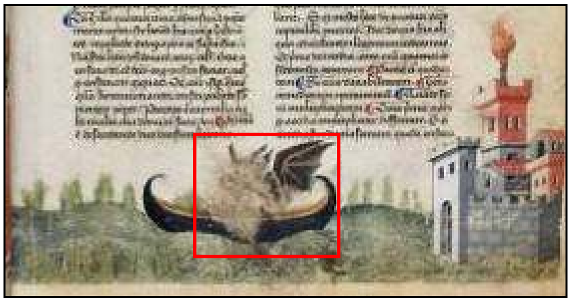
Virgil's impression of the boatman's age might have faded, were it not for the popularization of Dante's Divine Comedy (Chapter 6, And Back to the Cross). As the first named character that Dante meets in Hell, Charon must be what literary critiques classify as a well-defined persona.

Note the proliferation of Charon's appendages.





Note the horns in "Charon, Dante, Virgil and other Souls in Charon's Boat," from a 1328-

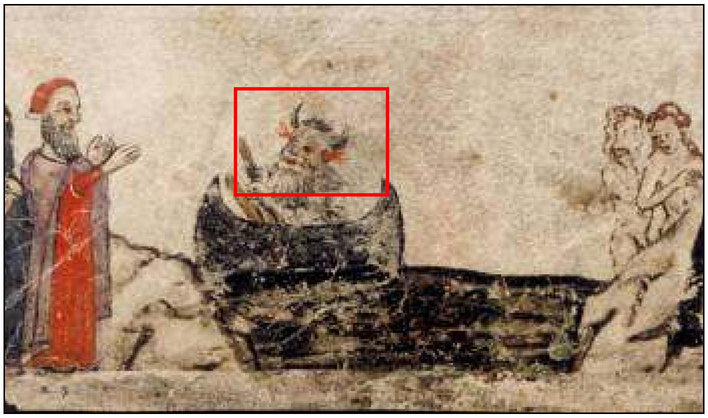


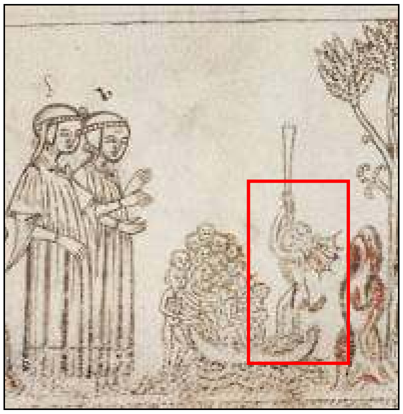
Note the black wings in "Phlegyas crossing the Styx." Per Chapter 1, in some Greek myth, the

1330 edition of the Divine Comedy. Chapter 6 provides thoughts on why Charon's assumed such fierce demeanor.

god Phlegyas assumes the role of boatman. In keeping with medieval art, the passengers -- insignificant mortals -- are miniature.

Below left, fire-emitting ears from another edition of the Divine Comedy. Below right, a tail.

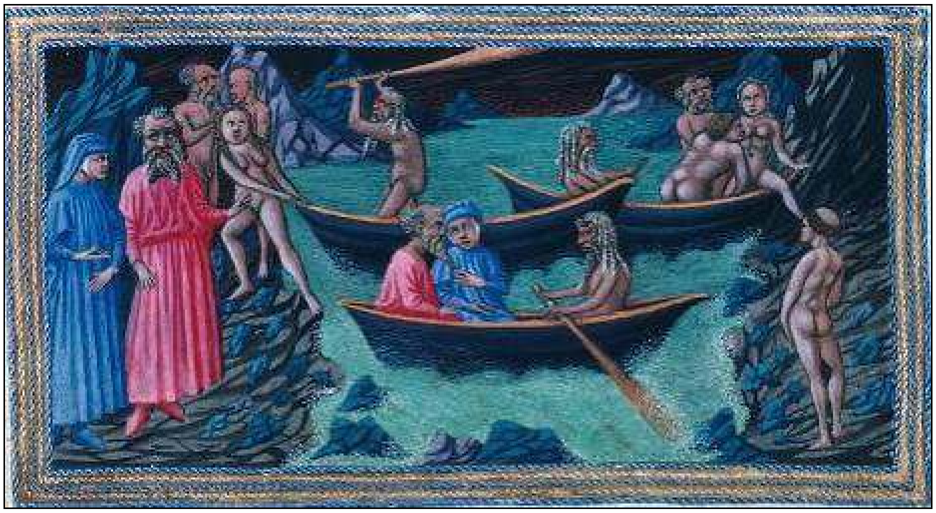




By Dante's day, the Church had robustly appropriated and manipulated themes of Greek lore to fit Papal dogma. The medieval Charon is a ruthless agent of Holy judgment, a galley slave for God.

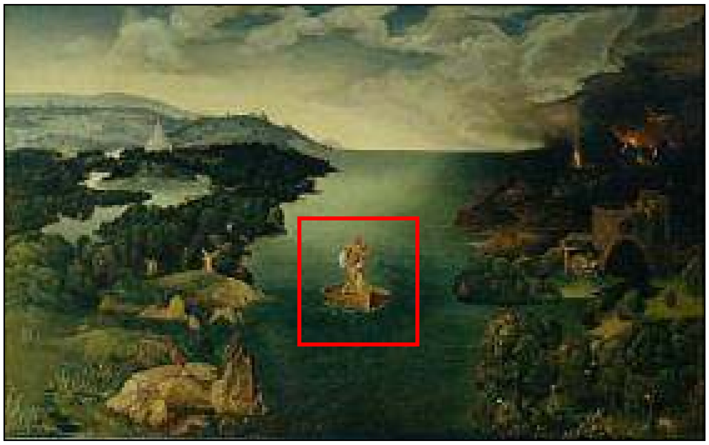
15th Century

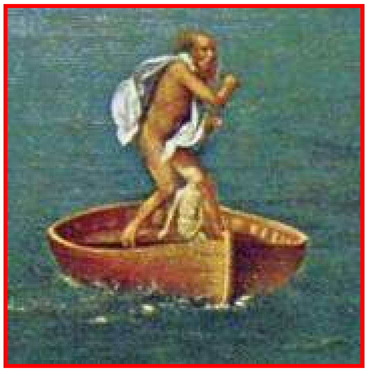
Priamo della Quercia's early Renaissance illumination shows three Charons, their wizened locks in ringlets. One dutifully conveys a righteous couple. Another disembarks passengers who, being nude, are to receive final judgment. A third threatens those who delay decision.



"Dante and Charon" (1442-1450), Priamo della Quercia

Renaissance artists more often took Charon to be avaricious, old and dirty, a grim gondolier laboriously pushing his skiff with a long pole. One or more diminutive, naked figures sit about him.

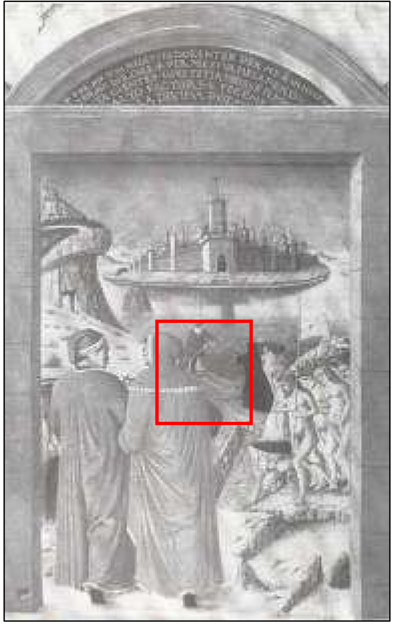




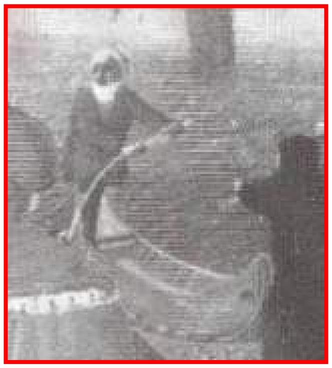
Detail

"Charon Crossing the Styx" (1475), Joachim Patenier

Patenier's Elysian Fields are "Christianized" with angels and a crystalline tower. On the other shore awaits a mouth-like cavern embellished with smoke, fire and infernal monsters. Charon's boat is poised midway. The small passenger, dwarfed by the ferryman, glances toward the gateway of doom, the human inclination toward sin.

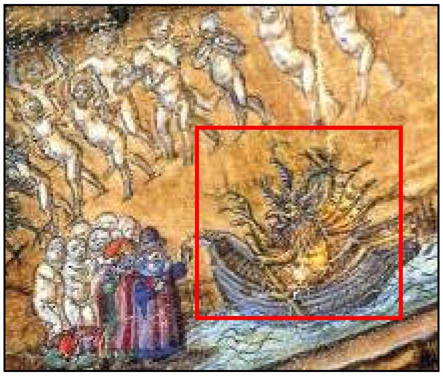


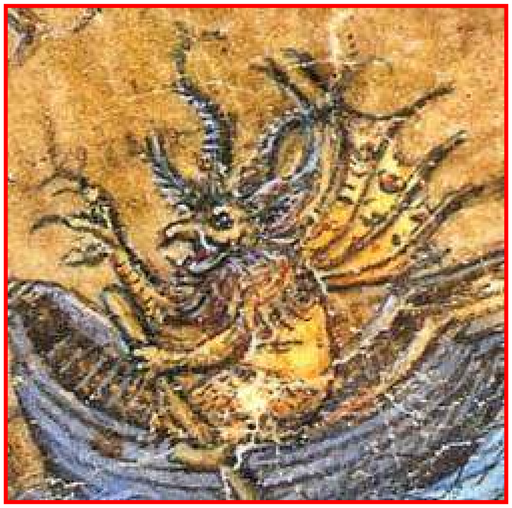
The illustration to the left shows Charon without distinguishing attributes, just a boatman of the era.

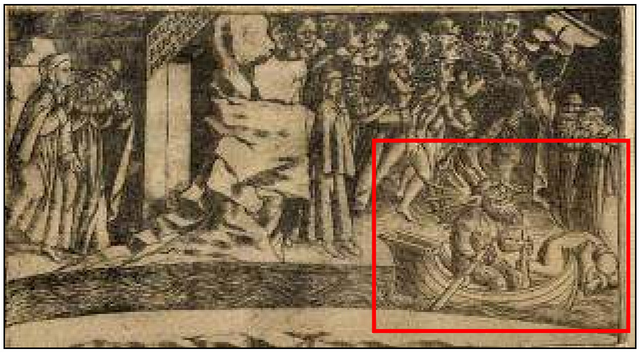


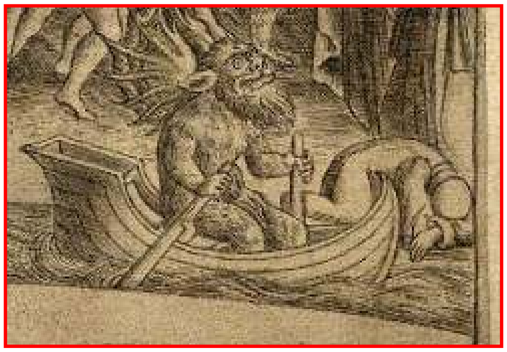
Guglielmos Giraldi (c.1478)

Sandro Botticelli's detail (c. 1480-1495) portrays a grotesque and monstrous boatman approaching the shore of Purgatory. Chapter 6, And Back to the Cross, shows the full work.



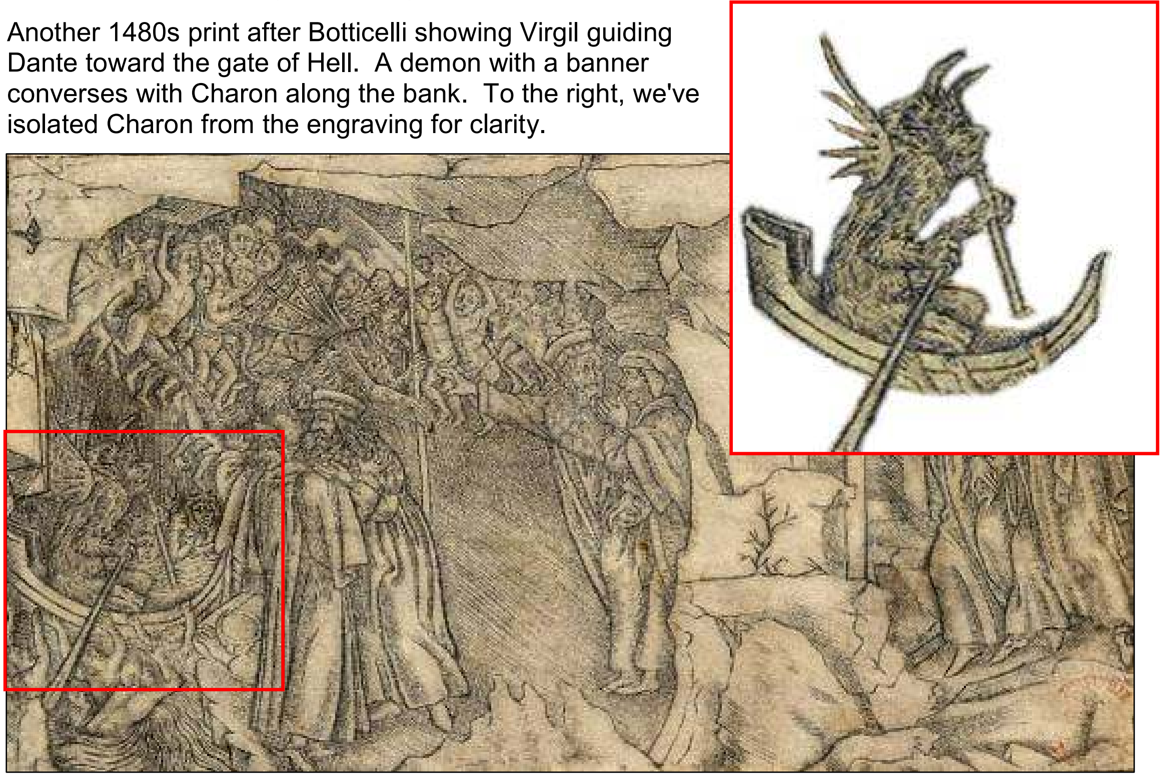


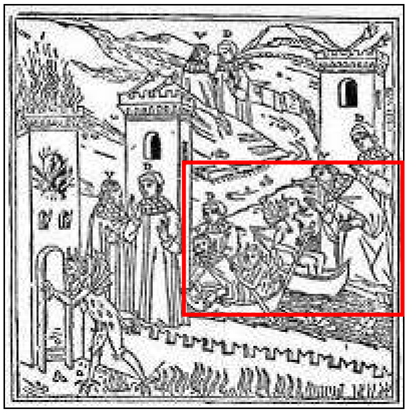


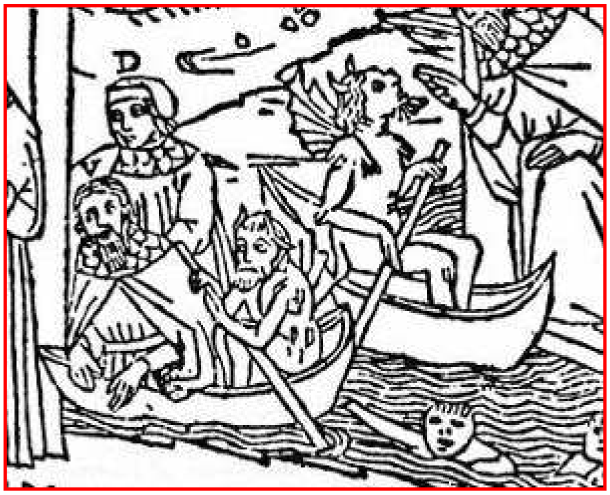


After Sandro Botticelli (1484-1487)

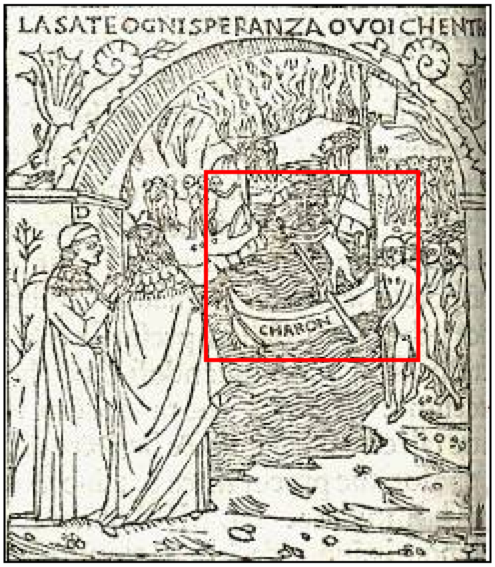
Another 1480s print after Botticelli showing Virgil guiding Dante toward the gate of Hell. A demon with a banner converses with Charon along the bank. To the right, we've isolated Charon from the engraving for clarity.







"Approaching the City of Dis" (1493)
Two Charons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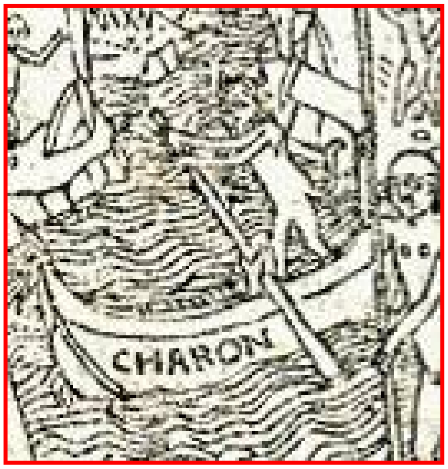
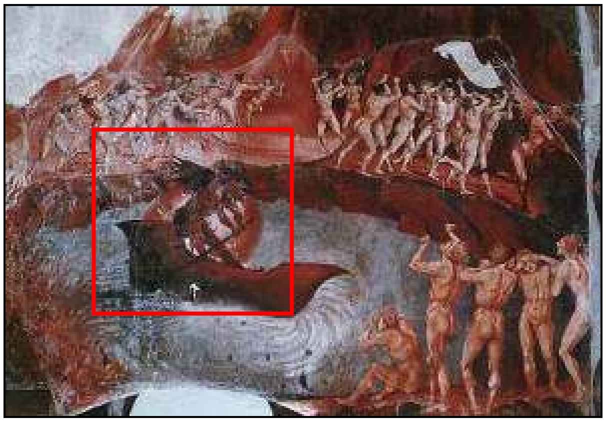
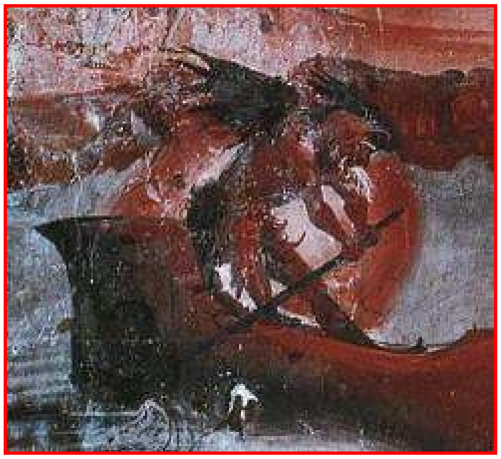


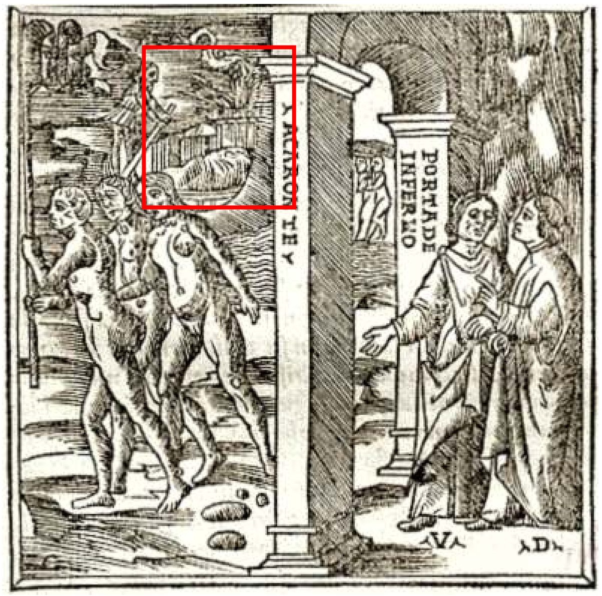
"Dante and Virgil go through the
Portal to Hell and See Charon" (1493)



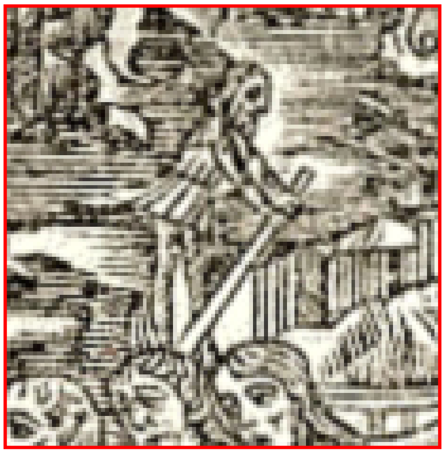


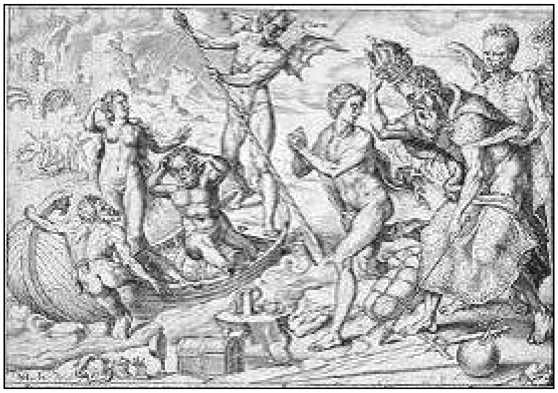
A portion of Luca Signorelli's fresco, "San Brizio Chapel, Charon and the Damned" (1499-1504)
The condemned languish on all banks. While in some myth, Charon labors on a lake, most artists preferred a river, perhaps because it allowed contrasting shores.

16th Century

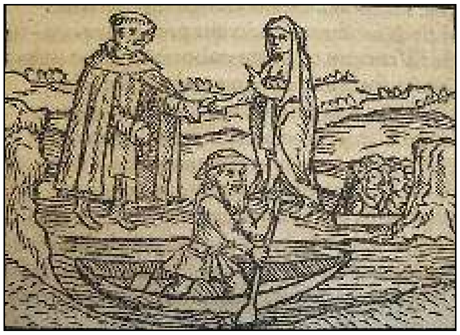


"Dante and Virgil See Charon Ferrying Souls across the Acheron" (1512. Dante's river is the Acheron, not the Styx, as discussed in Chapters 1 and 6.

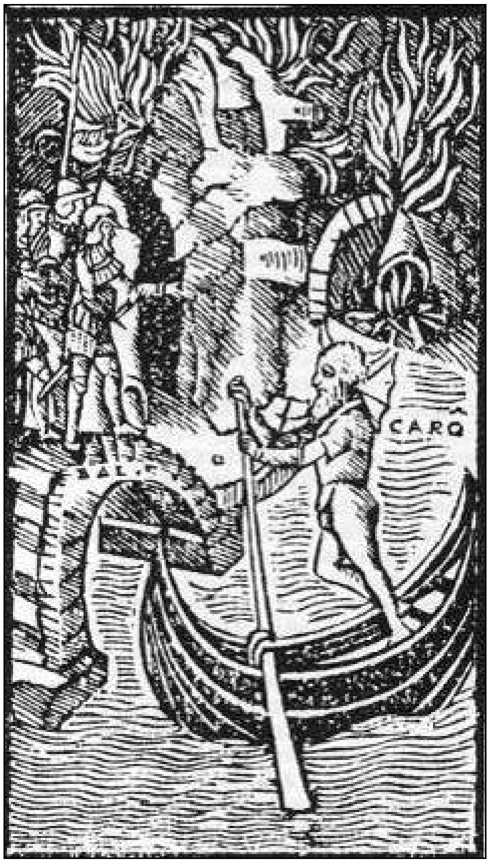




Etching by Philipe Galle. Charon is again winged



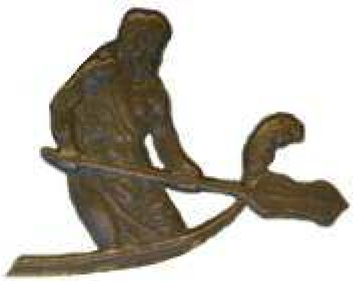
"Parable of Dives and Lazarus," woodcut by Jacob Locher. Meeting Charon, however, isn't a feature of the Luke 16 parable.



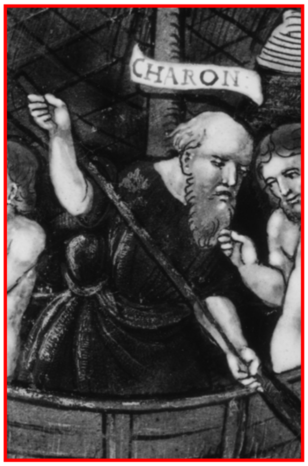
"Charon Comes to Ferry the Heroes" (1521) by Teofilo Folengo shows a boatman attired per the era.

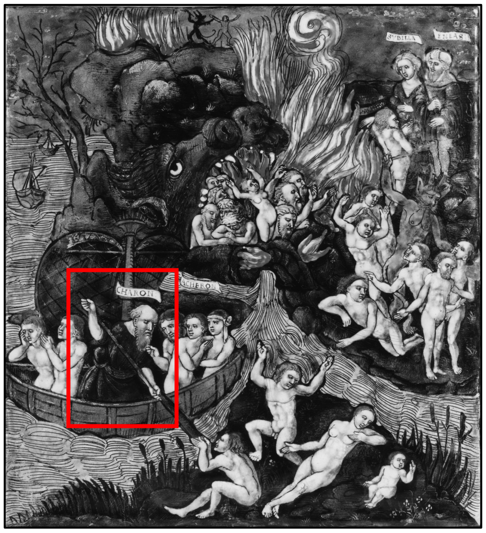
An early 16th century medallion depicting Aeneas and the Sibyl Cumana entering Charon's boat in the legend of Orpheus.

We've pulled Charon out to better see him.

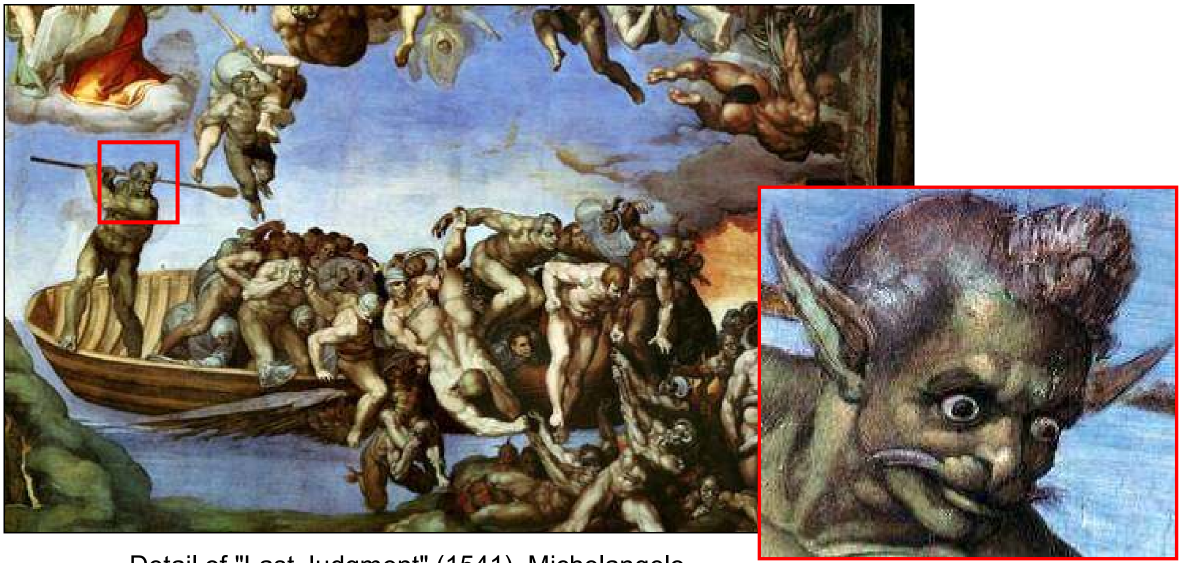


The Charon of "Descent of Aeneas into Hell" (c. 1530) appears not to be old.





Influenced by Dante's “batte col remo qualunque s'adagia,” Michelangelo's "Last Judgment" Charon is more than a toiler; he's a man of mission, oar raised to smite those who wish to rest.



Detail of "Last Judgment" (1541), Michelangelo

But before the plaster in the Sistine Chapel was yet dry, controversy surrounded the work. According to Papal Master of Ceremonies, Biagio da Cesena,

> *It was mostly disgraceful that in so sacred a place there should have been depicted all those nude figures, exposing themselves so shamefully, and that it was no work for a papal chapel but rather for the public baths and taverns*,

Just a month before the artist's death, it was decided to "amend" the fresco and Daniele da Volterra added loincloths. Over the years, additional portions were "amended," but during the restorations in the 1980s and 1990s, the masterpiece was largely returned to its original state, leaving only the changes made by da Volterra.

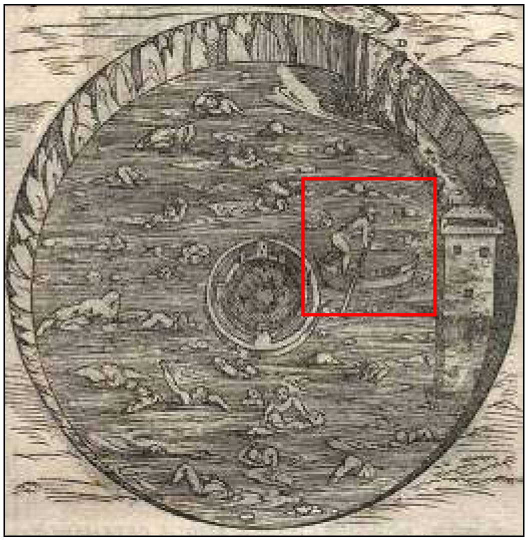
Iconografia Dantesca, The Pictorial Representations to Dante's Divine Comedy (1899) by Ludwig Volkmann has this to say,

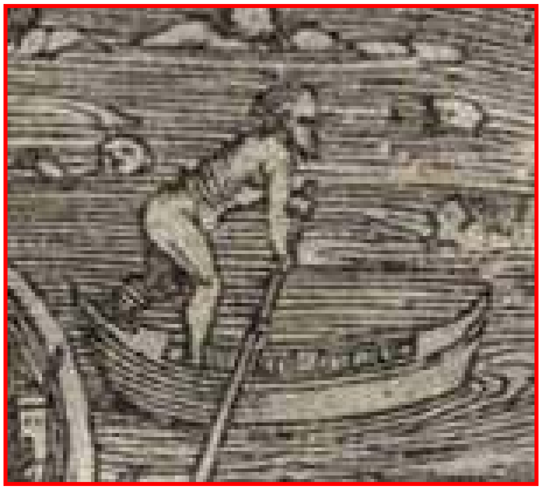
> *One can see the ferryboat of Charon, from which the damned are thronging in masses. The somber ferryman of the nether world himself is faithfully depicted after Dante, as he beats with his oar every one who hesitates. This splendid motive had been almost universally allowed to pass unnoticed by artists previously. Most of the manuscripts present Charon simply as a rowing devil; and even in the rare cases where there was a suggestion of the beating with the oar, this is so stiffly and awkwardly done that one cannot really call them worthy representations of Dante's Charon as yet. Michael Angelo was the first to give him classical form, and all later men followed him in this.*

According to Francis A. Sullivan in "Charon, the Ferryman of the Dead," Classical Journal, October 1950,

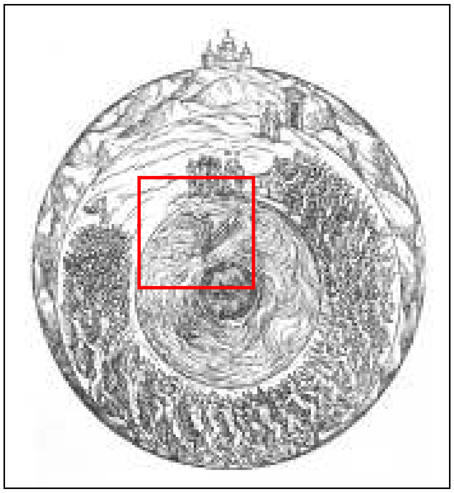
> *The Christian view of Charon has naturally softened the features of the character ascribed to him, and many a folk tale tells how unwilling he is to carry off his victims. But no respite can he give, for he is straightly charged by God to ravish souls. The modern pagan conception of him is darker and excludes all traits of kindliness and mercy. Men hate him as the inexorable hunter whose quarry is human souls, or the warrior whom no human prowess can overthrow, no beauty soften.*
>
> *Charon, the old boatman of the Styx, seems to have suffered a great sea-change down the centuries.*

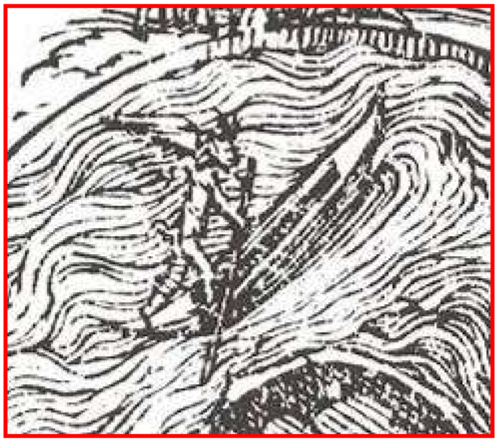
The closing line, of course, summarizes the theme of this chapter.





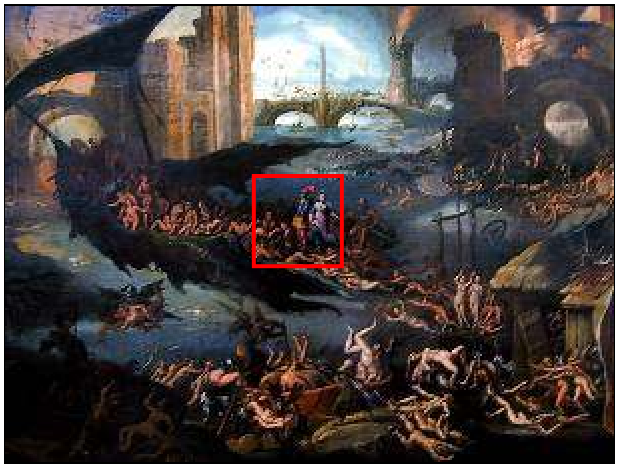
Francesco Marcolini (1544)



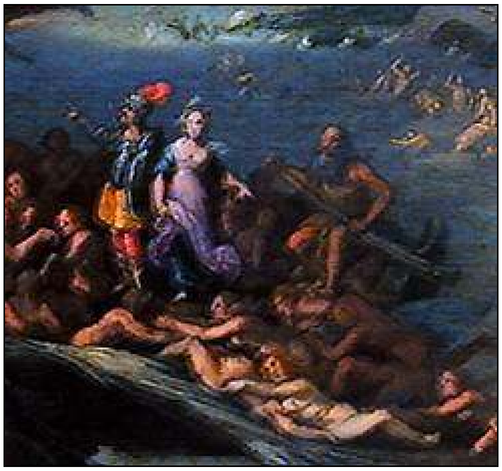


Venice woodcut (c. 1544)

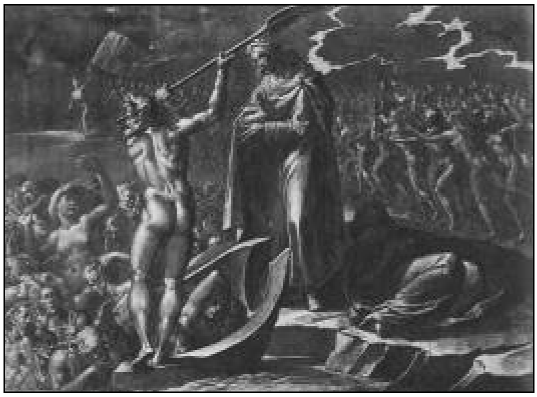
The painting below bears hallmarks of a Brueghel, but is by a lesser-noted contemporary.

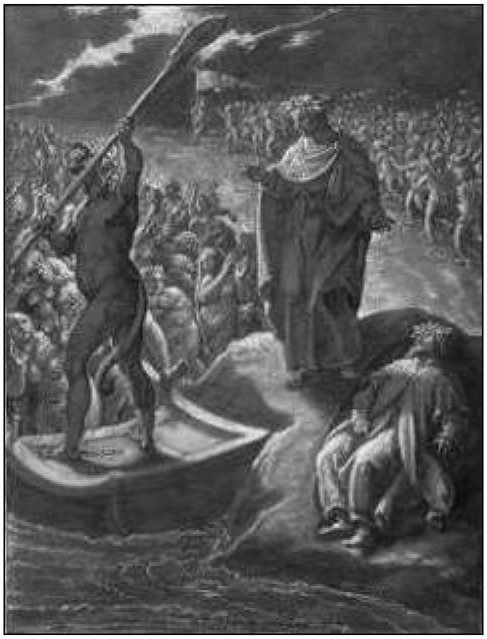


"Aeneas and the Sibyl enter Hades" (1571)
Jacob Isaacsz van Swanenburgh



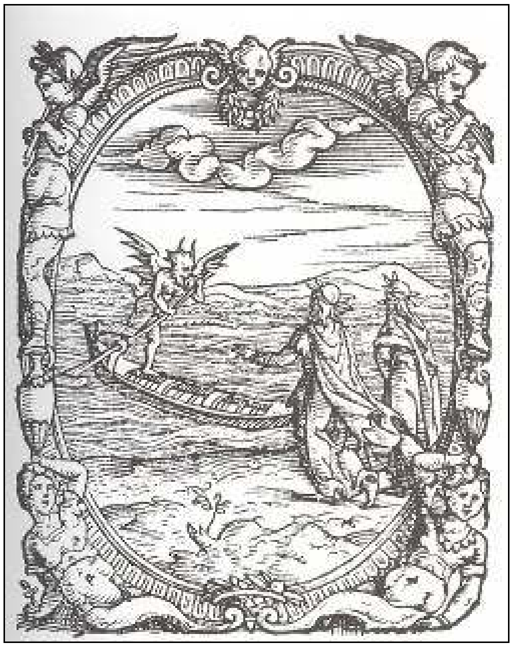
Detail of Aeneas and the Sibyl on Charon's boat through the River Styx



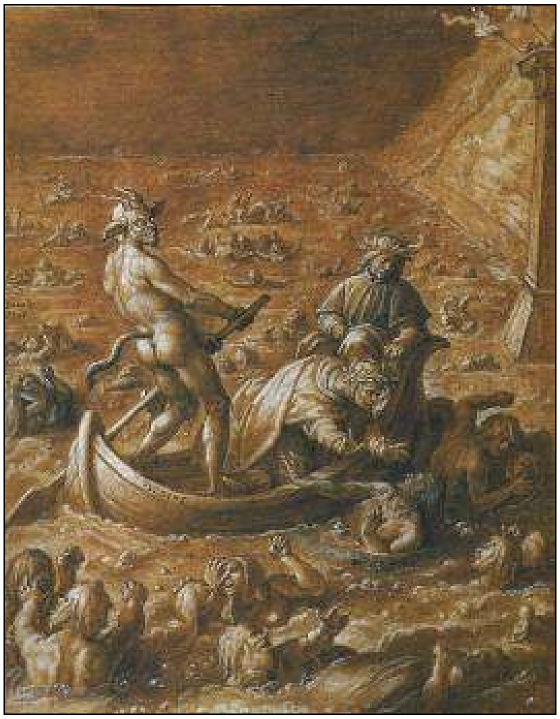


In "Dante and Virgil on the Shores of Acheron" (1588) by Jacopo Ligozzi, Charon smites those who linger while Virgil seeks to arrange for passage and Dante falls into a swoon.

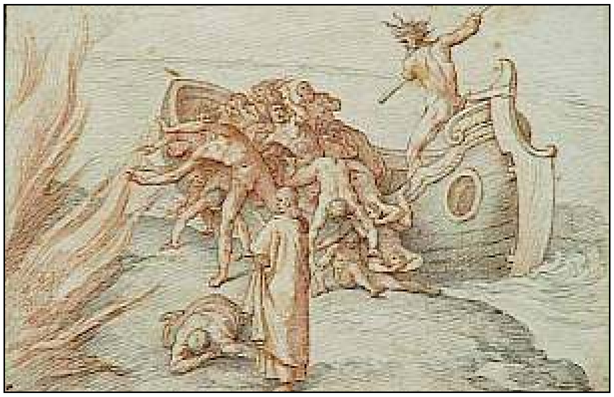
Artistic plagiarism was commonplace. The Charon to the right, however, from another edition of the Divine Comedy, sports a tail



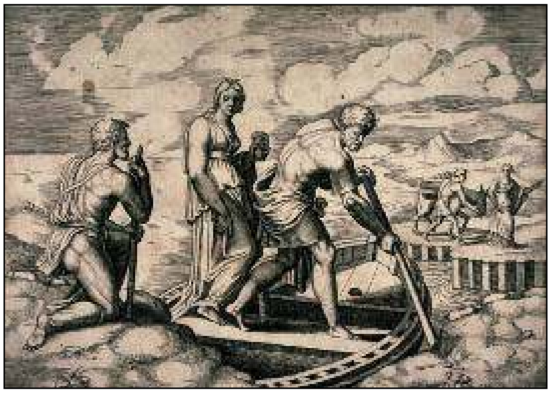
Venetian woodcut (c. 1555)



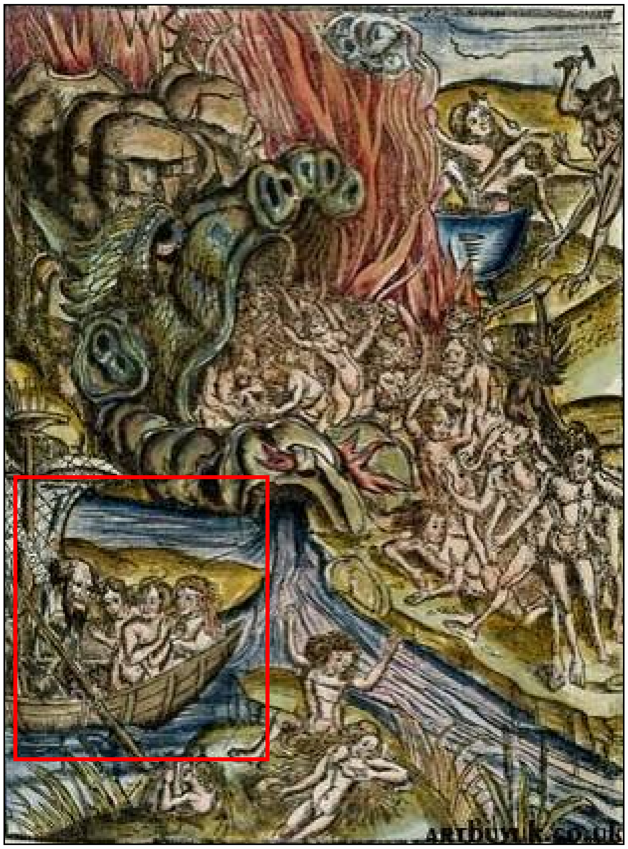
Another 16th-century tailed Charon.



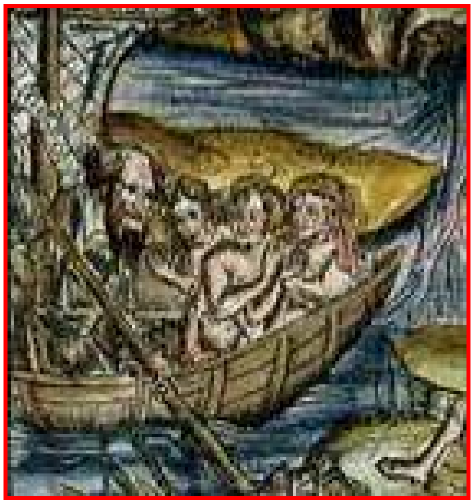
Federico Zuccaro (c. 1587)



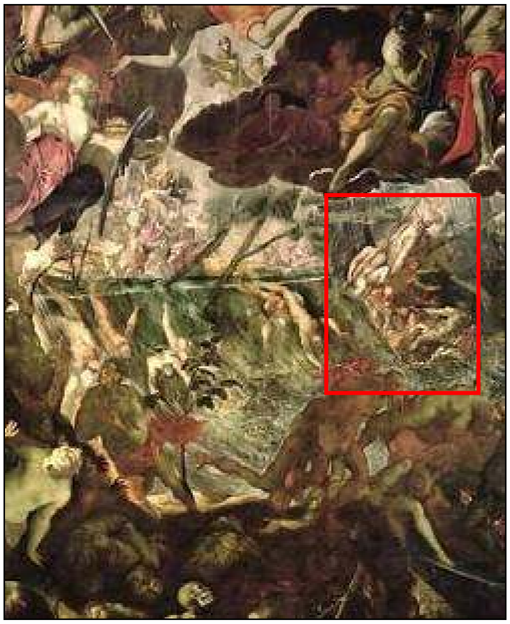
"Psyche Embarks in Charon's Boat,"
Bernardo Daddi (1512)



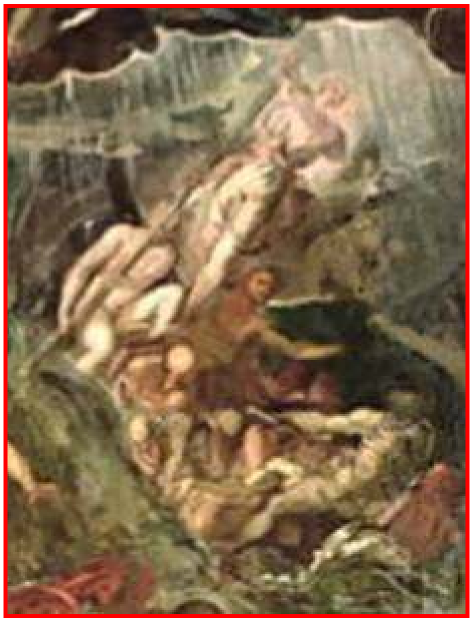
While many of the era's pieces clung to established styles, the hand-colored woodcut "Charon, the Ferryman of the Underworld, in Hell" (1535) is evidence of a new surrealism.



Tintorreto's figure-laden composition below foreshadows a changing artistic eye.



"The Last Judgment, Detail of the Damned in the River Styx" (before 1562), Domenico Tintoretto.

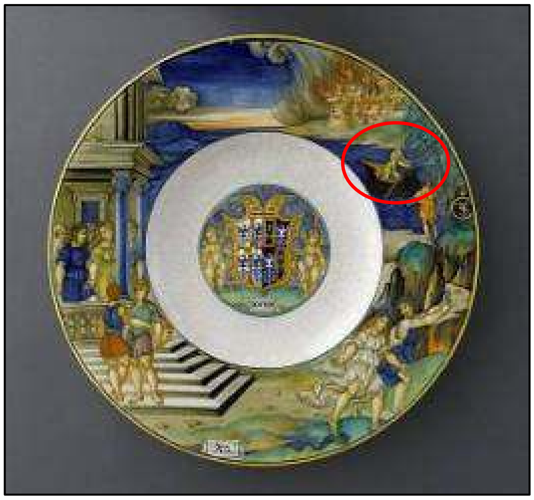


The feeble boat, beyond the power of the helmsman to control and laden with derelict souls, drifts to endless damnation.

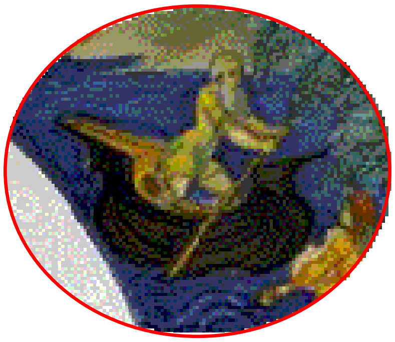
Tintoretto's contemporary, Giorgio Vasari's Lives of the Artists, wasn't impressed.

> *There, also, may be seen the boat of Charon, but in a manner so different from that of others, that it is a thing beautiful and strange. If this fantastic invention had been executed with correct and well-ordered drawing, and if the painter had given diligent attention to the parts and to each particular detail, as he has done to the whole in expressing the confusion, turmoil, and terror of that day, it would have been a most stupendous picture.*

The painting is flawed, according to Vasari's, because it inadequately portrays Charon's craft a refuge upon the river.

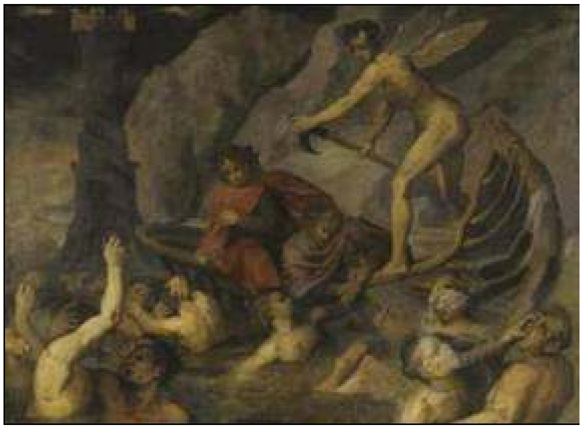


Not all art is on canvas or paper, as illustrated by Italian ceramicist Nicola da Urbino's "Orpheus and Eurydice" (1520-1538).

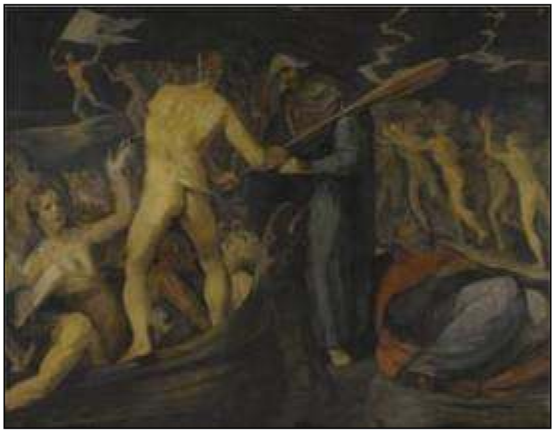


17th Century

Donato Mascagni (1579-1636) held closer to earlier motifs. Note Charon's style tail on the right.

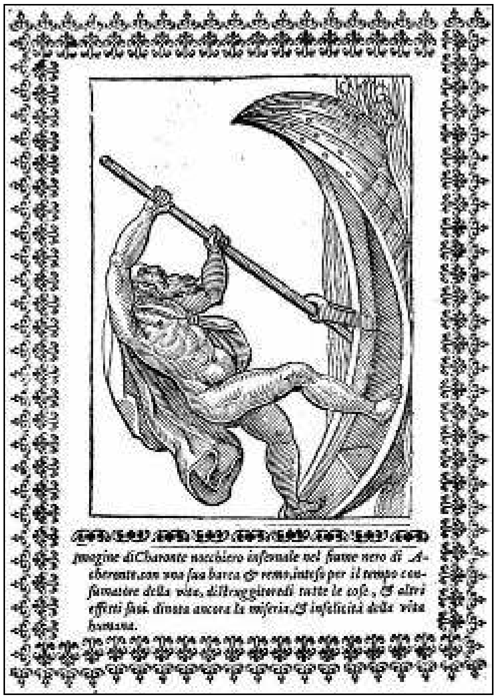


"Dante and Virgil about to Take Ship with Charon across the Acheron"



"Charon Ferrying Virgil and Dante across the Acheron"

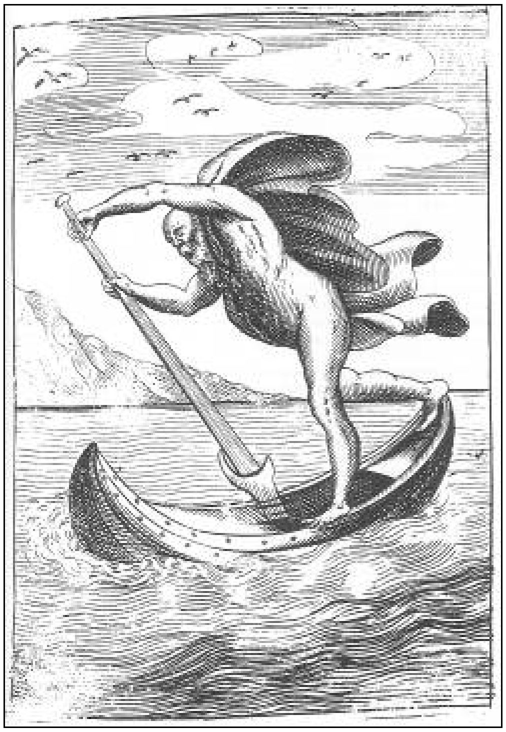
A pair of woodcuts, heroic in Charon's toil, nearly identical in composition,



Imagine diCharonte nocchiero infernale nel fiume nero di A-cheronte,con vna ſua barca & remo,inteſo per il tempo conſumatore della vita, diſtruggitore di tutte le coſe, & altri effetti ſuoi. dinota ancora la miſeria,& infelicità della vita humana.

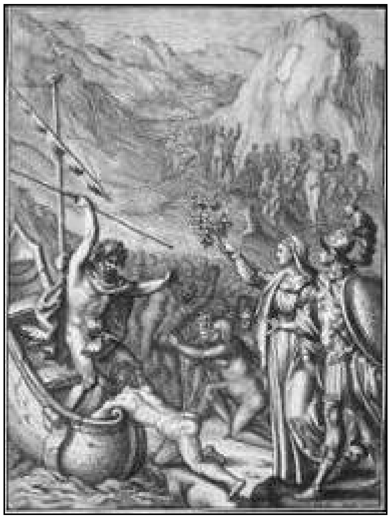
"Charonte" (1615), Filippo Ferroverde

The format brings to mind the trading card of Chapter 27.

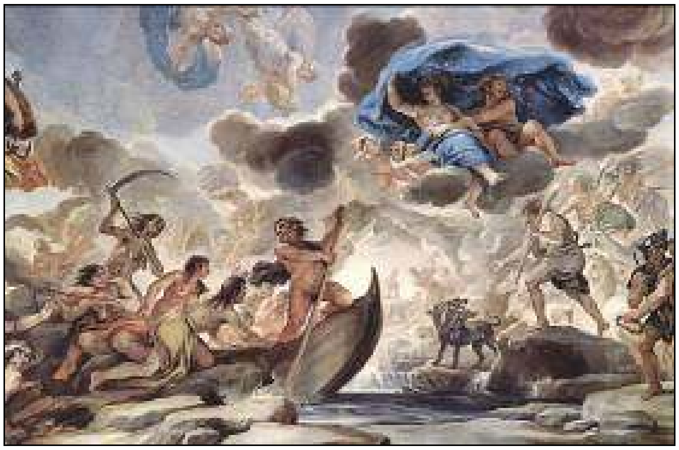


"Of the Ancient Images" (1603), Vincenzo Catari

The works below are sophisticated in story, but reveal little novel regarding the boatman.

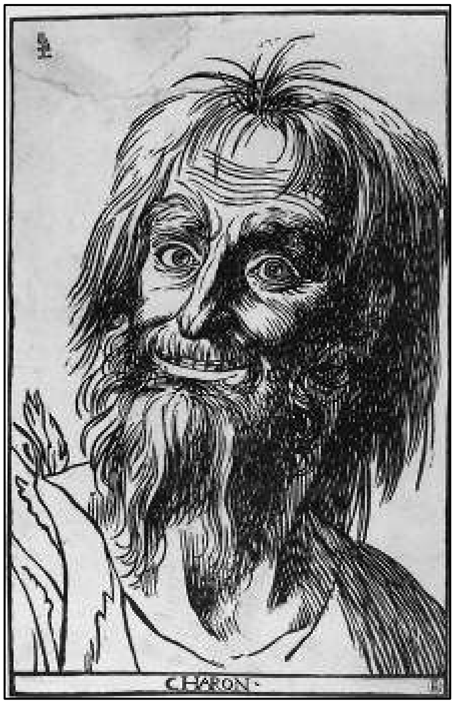


"Aeneas and Charon" (17th century)
Wenzel Hollar

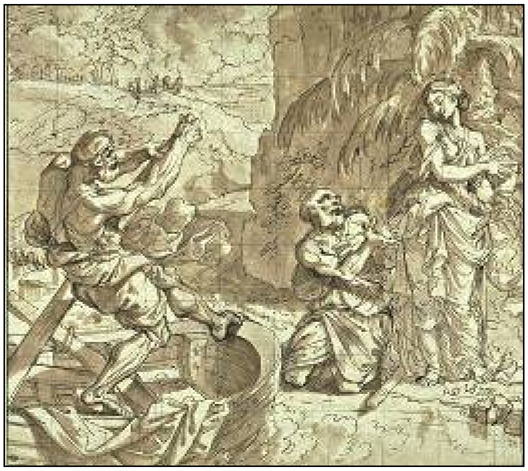


"Entrance to Erebus" (1684-1886)
Luca Giordano

The woodcut to the right, "Charon" (c. 1620) by Werner Van Den Valckert makes Charon less the heroic boatman, and more the bemused observer.

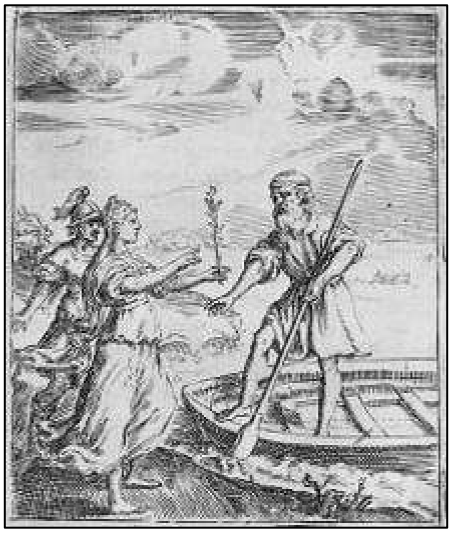


Below, "Psyche with the Water of the Styx, after Crossing into the Boat of Charon" (17th century), Jean-Baptiste Corneille

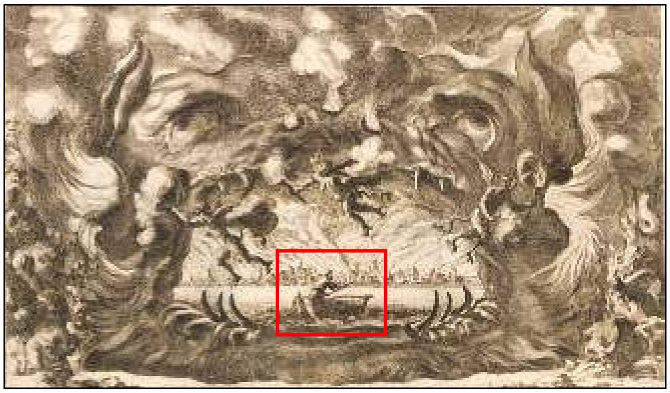


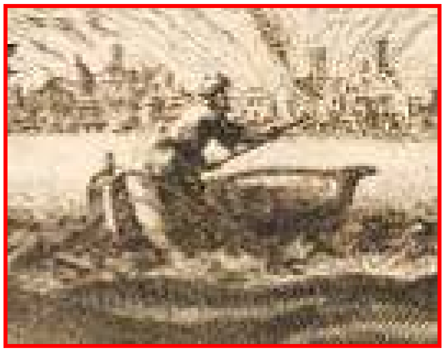
"Charon Taking as Passengers Aeneas and the Cumaean Sibyl" (1628) by Oliviero Gatti, is more-representational of emerging Romantic movement.

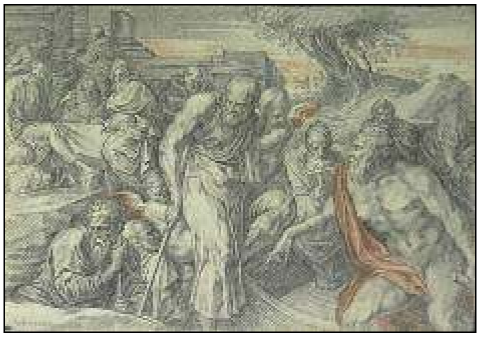
We don't today associate this softer side with our brusque oarsman, but when Orpheus sought his deceased wife, Eurydice in Ovid's Metamorphoses, Charon was so charmed by his music that he ferried for free. Even the most curmudgeon retains a spot of vulnerability, a touch of the humanistic 1600s.



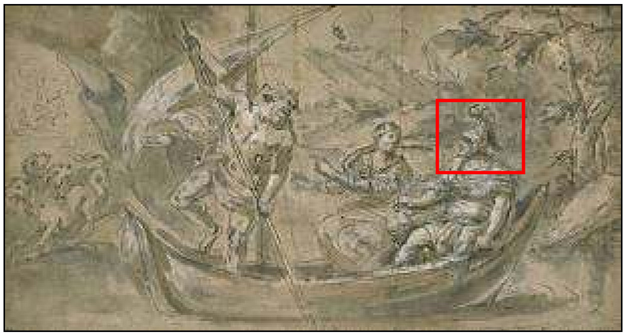
Below, the "Golden Apple" (1668), after Burnacini, portrays Charon alone, the city on the far shore seemingly not Dante's Dis, but a place of refuge.



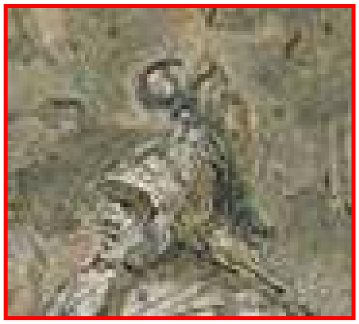




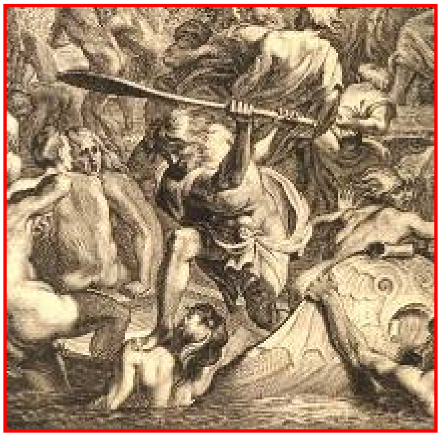
Abraham van Diepenbeeck, "The Boat of Charon" (17th century), the boatman accentuated in red.

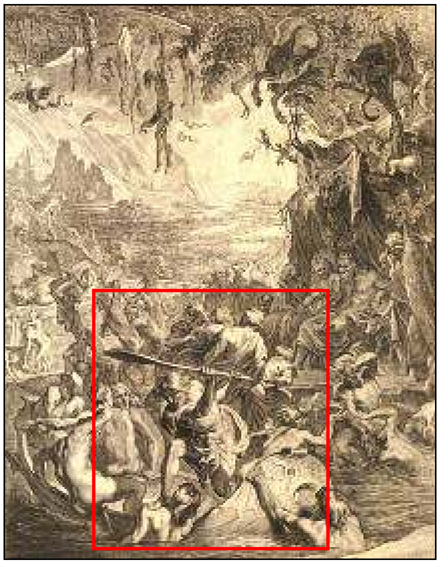


Attributed to Ciro Ferri "Charon Leading Aeneas and the Sibyl in the Underworld" (17th century). Note the Roman helmet.

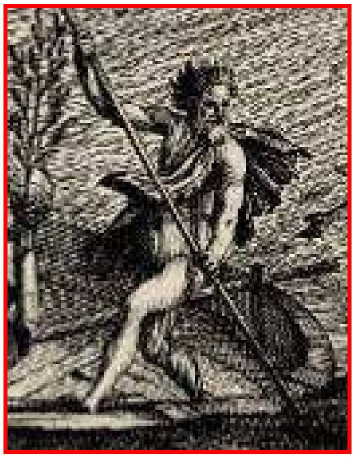


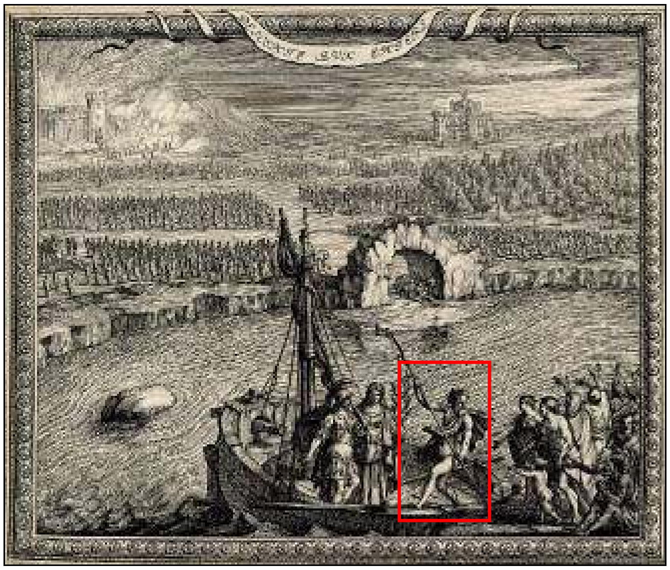
"The Underworld" (1635-1638), after van Diepenbeeck, Charon, repelling souls trying to board. Hades and Persephone are under a canopy of flayed skin. Torture scenes fill the middle.





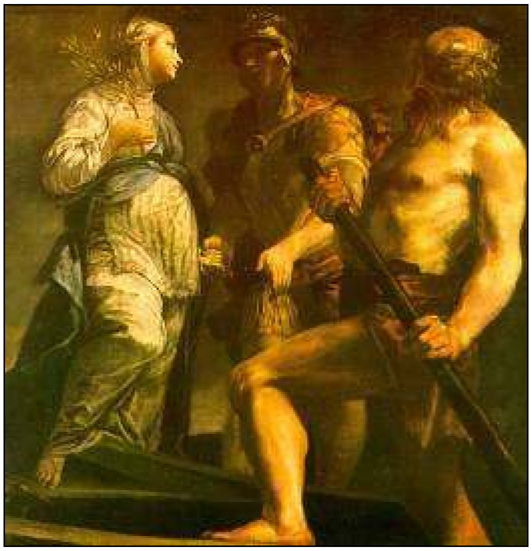
"Descent to Hell" (1648), below, is unknown. Charon poles a vessel of the era.





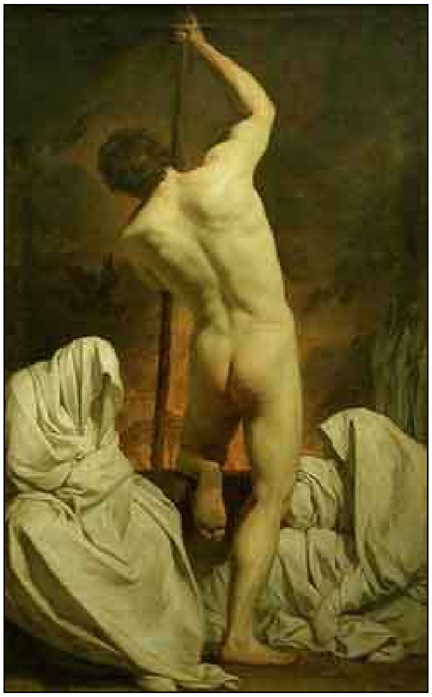
18th Century

The 1700s was a century of neoclassical revival.



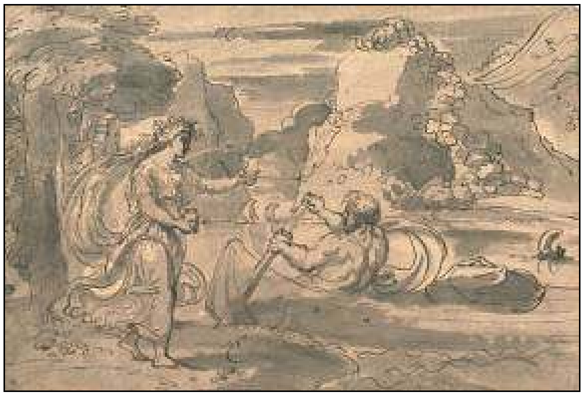
"Aeneas with the Sybil and Charon" (c. 1700), Giuseppe Maria Crespi

Crespi's painting serves to model the bodies with plasticity, and above all to structure the surface of the picture into light and dark patches, into bands of light, as if the physical connection and hence the connection with regard to content were becoming secondary -- pointers to the new century that was about to start. -- Wolfgang Prohaska, Kunsthistorisches Museum, Vienna, The Paintings (2006)

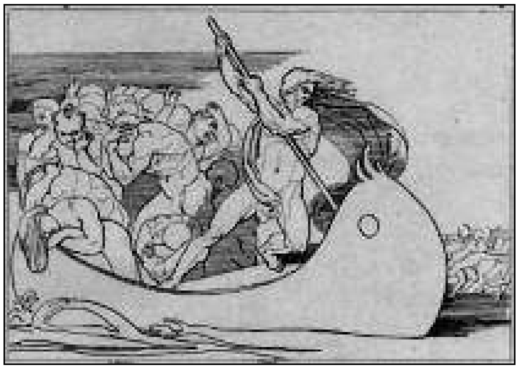


"Charon Ferrying Dead Souls across the Styx" (1732), Pierre Subleyras

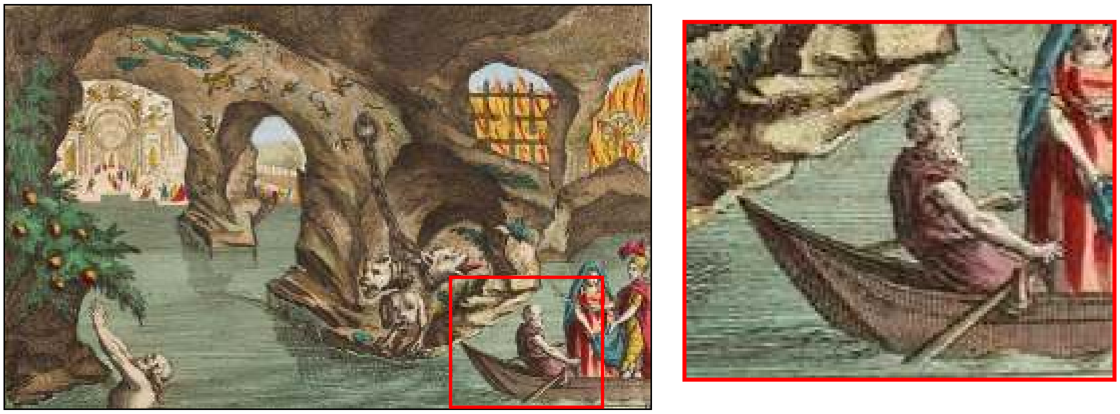
Between late-Baroque and early-Neoclassic, this Charon seems in the prime of vitality.



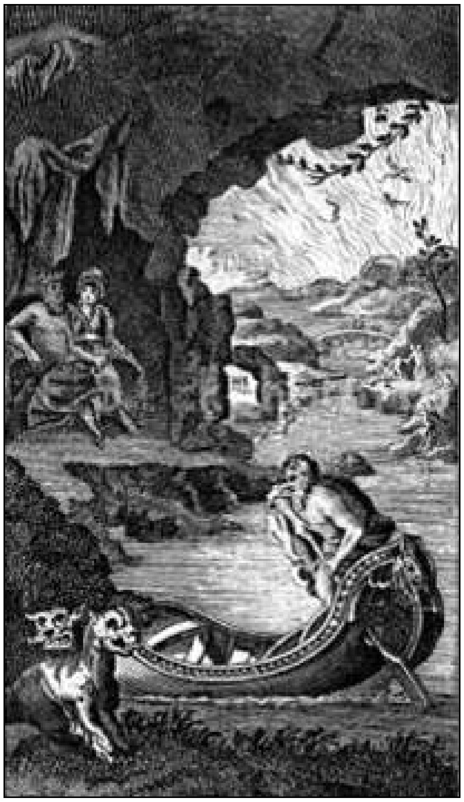
Michel Corneille the Younger, "Psyche asking to pass the Styx" (early 18th century)



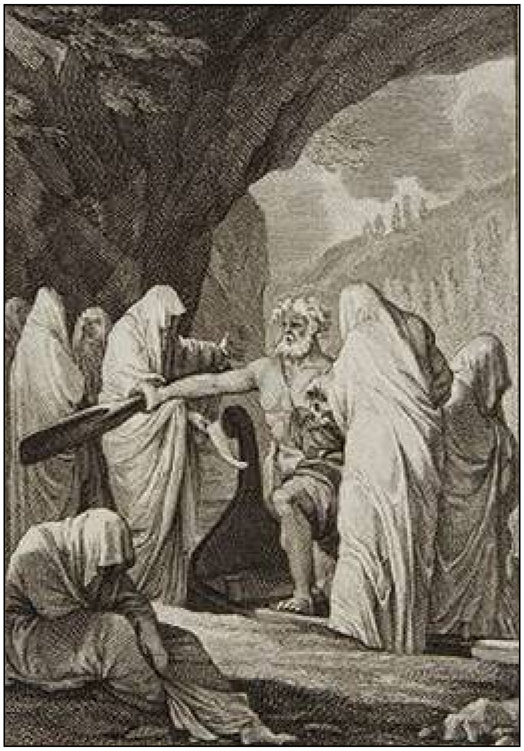
"Charon Ferries the Damned across the Acheron" (1793), John Flaxman. For the era, a rare instance of less cluttered imagery



"View of Hell with the Palace of Pluto in the Distance" (third quarter, 18th century), Jacques-Gabriel Huquier.

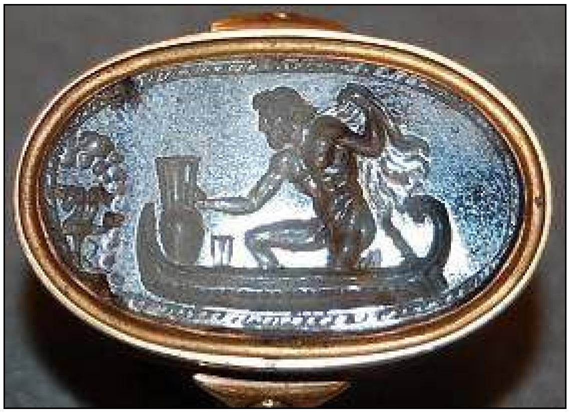


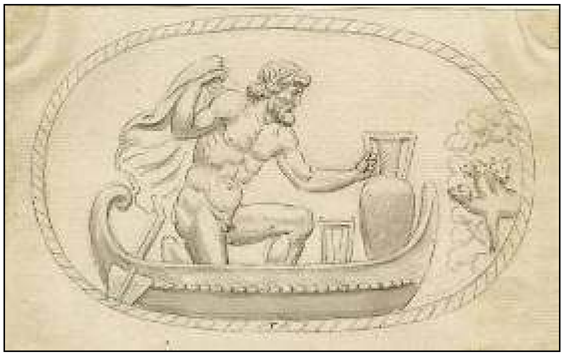
Engraving (18th-century)



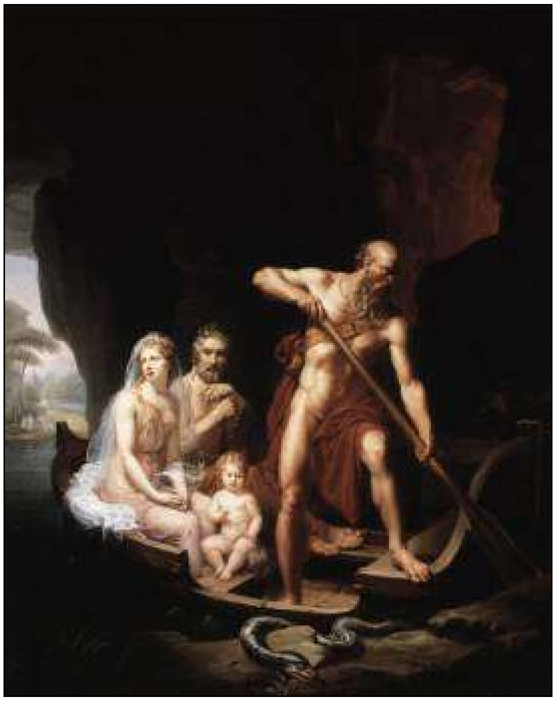
"Charon Ferries the Shades," Lettres à Emilie sur la Mythologie (1786-98), Remi Henri Joseph Delvaux

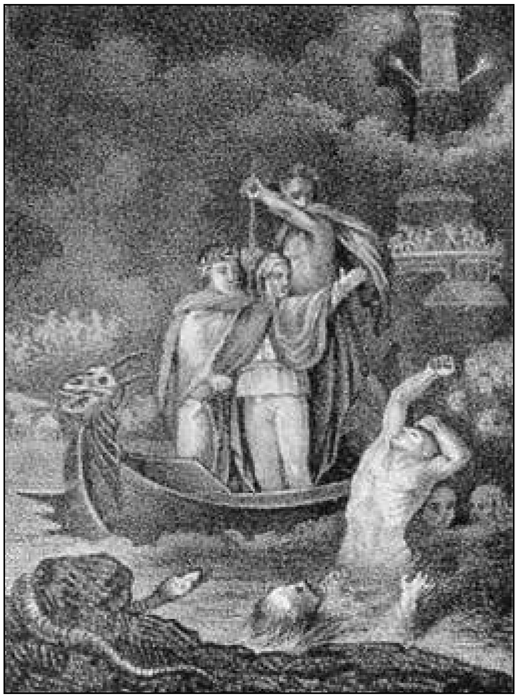
A pair of neoclassical scarab renderings of Charon confronting the half-woman, half-serpent Cerberus.





19th Century





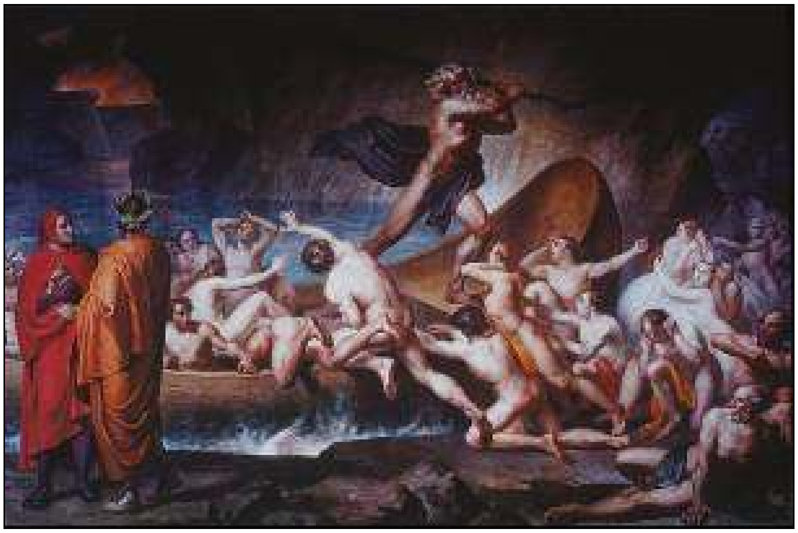
"Passage on the River Styx" (1819), Nicolas-Louis-Francois Gosse

Charon appears to have forgotten his charge and now transports the Holy Family.

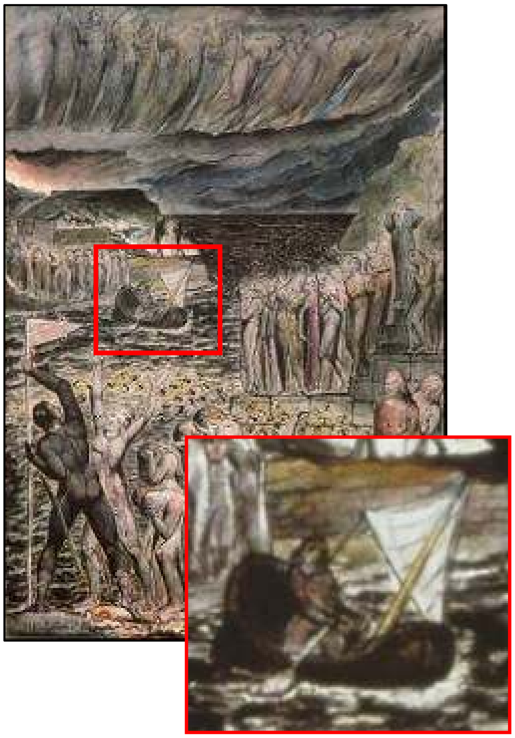
"Filippo Argenti Trying to Get into the Boat" (1838), Federico Zandomenegh

The snake lurks in both works.

"Bark of Charon" (19th century), Filippo Bigioli

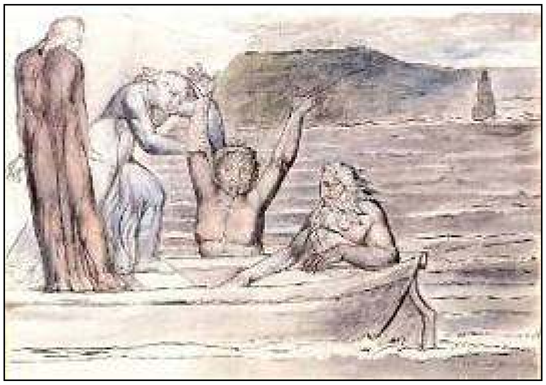


The three Divine Comedy illustrations below were engraved by William Blake, 1824-1827.

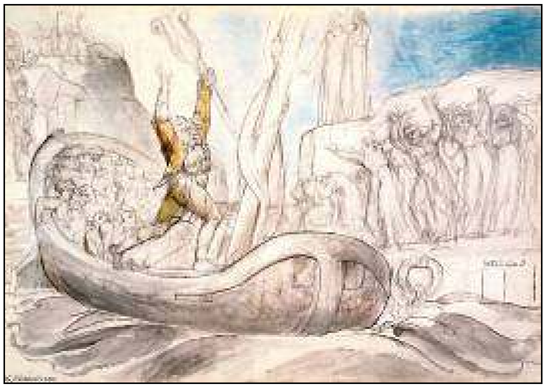


"Vestibule of Hell and Souls Mustering to Cross Acheron"

The detail shows what may be a unique nautical outing for Charon, sailing.



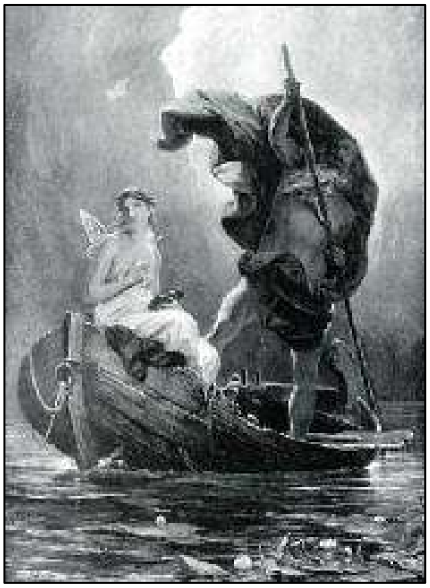
"Dante and Virgil are Hailed by Filippo Argenti"

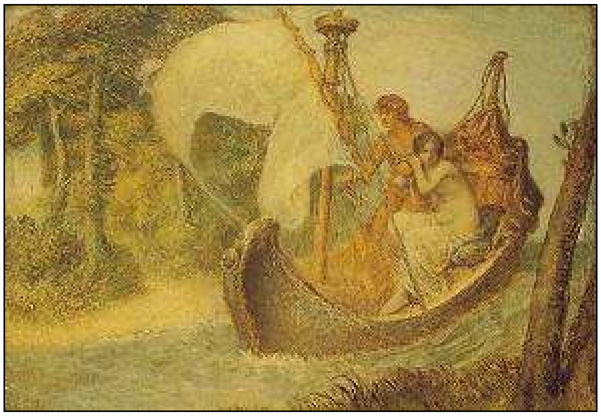


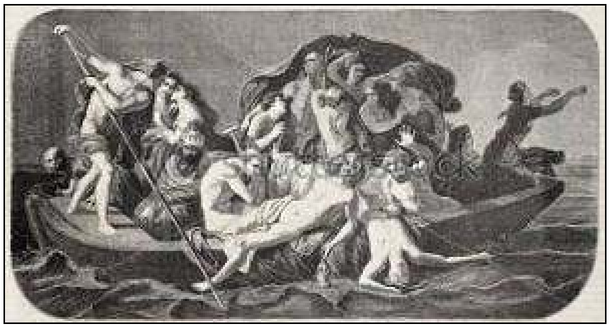
"Charon and the Condemned Souls"

Edward Calvert's "The Soul Crossing the Styx" (1844-1883) is to the right, Charon's face shrouded in his cape, his passenger, angelic.

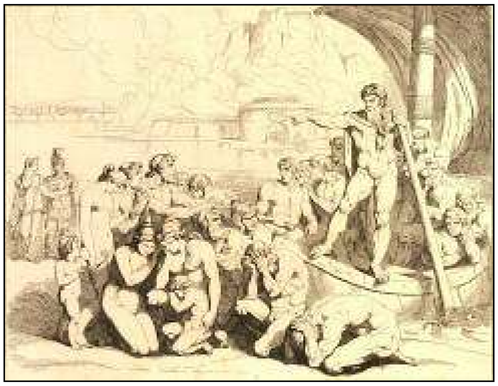
Below is another Calvert, less-foreboding.



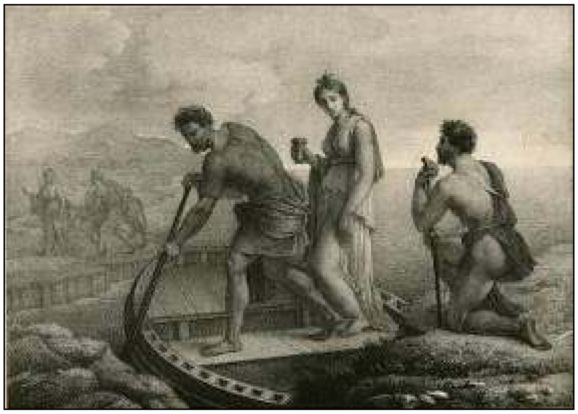




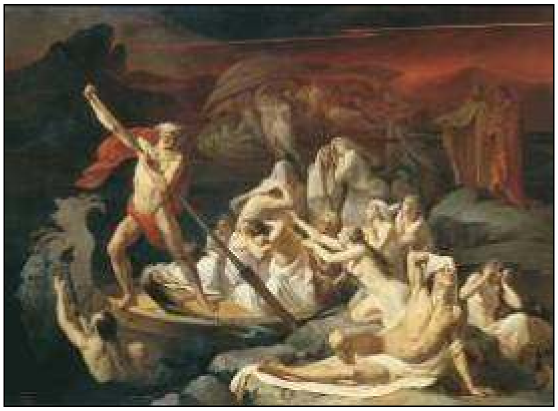
"Charon's Boat," Auguste Feyen-Perrin (1826-1888)



Aeneid print by Bartolommeo Pinelli, 1811. Charon commands condemned souls to return to land.

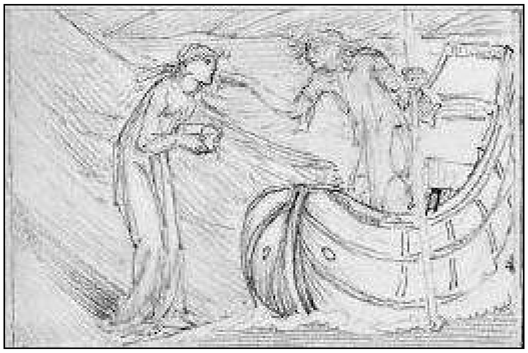


"Psyche Crossing the Styx," The Loves of Psyche, after Raphael (1825)

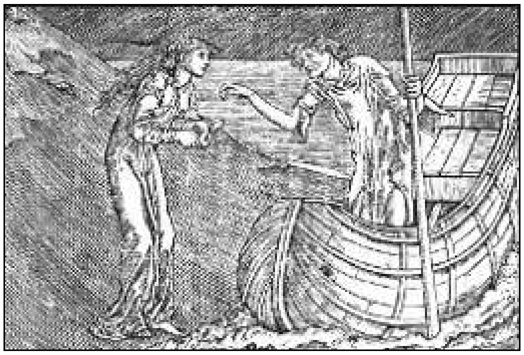


"Charon's Crossing" (1861), Alexander Litovchenko.

The etching and wood-cut below are by Edward Burne-Jones. In the former, Charon takes the coin out of Psyche's mouth, whereas in the latter, she holds it in her hand.

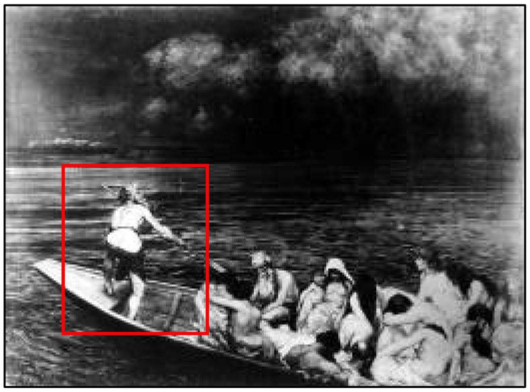


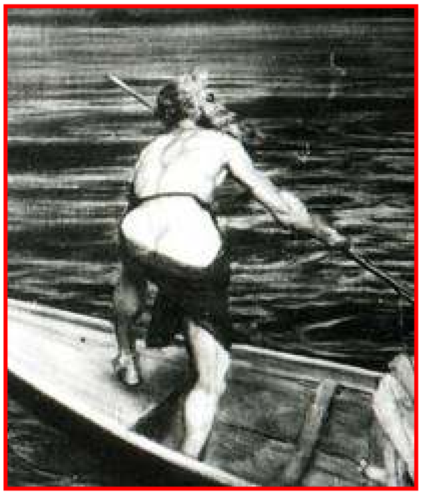
"Cupid and Psyche" etching (1865)



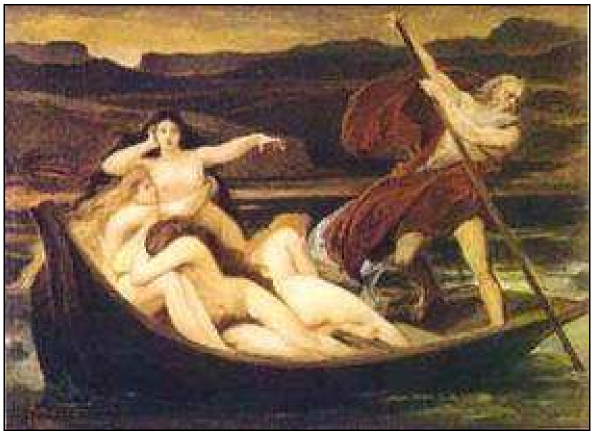
"Cupid and Psyche" woodcut (1880)

Unlike Burne-Jones prints which hearken to centuries of Dante illustrations, the 1876 etching by Hans Thoma is almost photographic in tone.

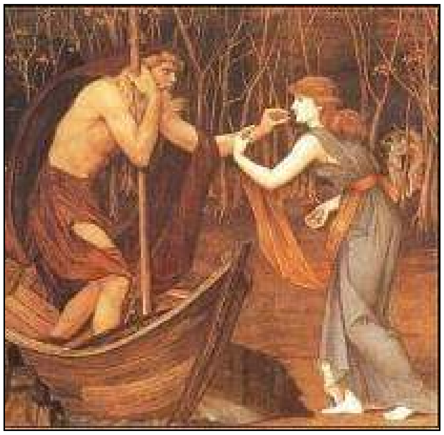




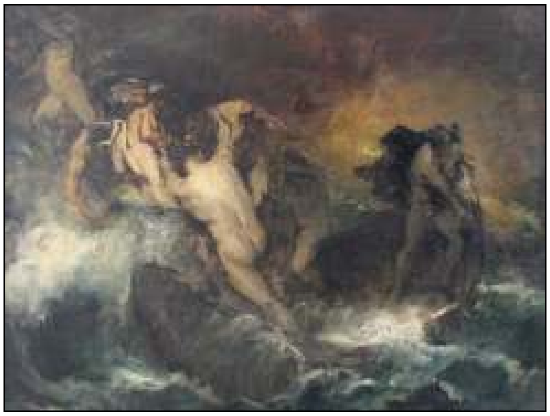
Below, however, we see that classicism persists.



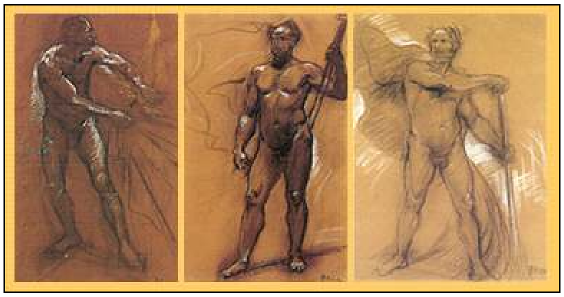
"Charon Crossing the Acheron" (1882),
Pedro Americo



"Charon and Psyche" (1883),
John Roddam Spencer Stanhope

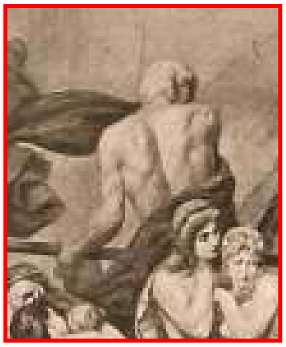


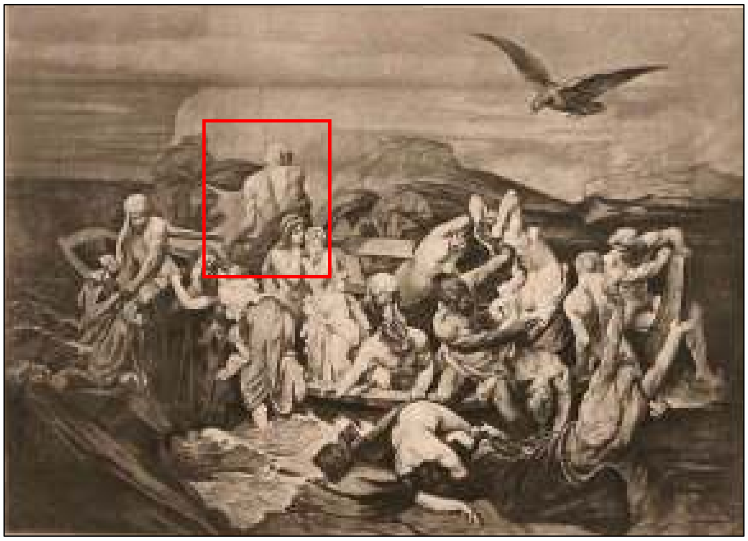
"The Boat of the Acheron" (1887),
Felix Hildago



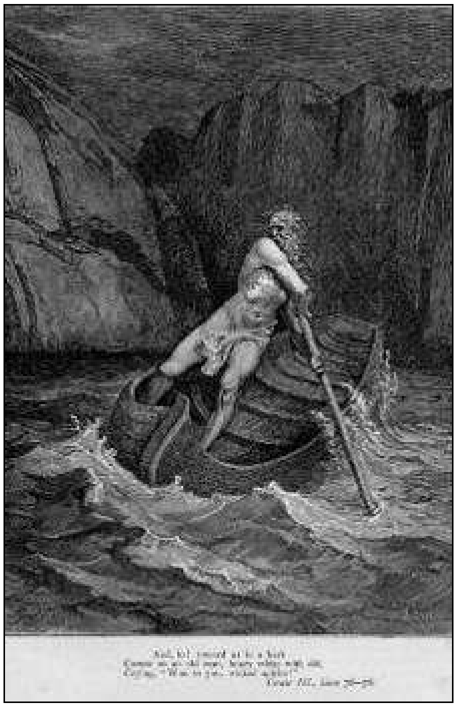
Hildago's Charon studies

In "The Bark of Charon" (1895), photogravure by G. Pepperity. Charon turns from the carnage while the vulture eyes the spoils.



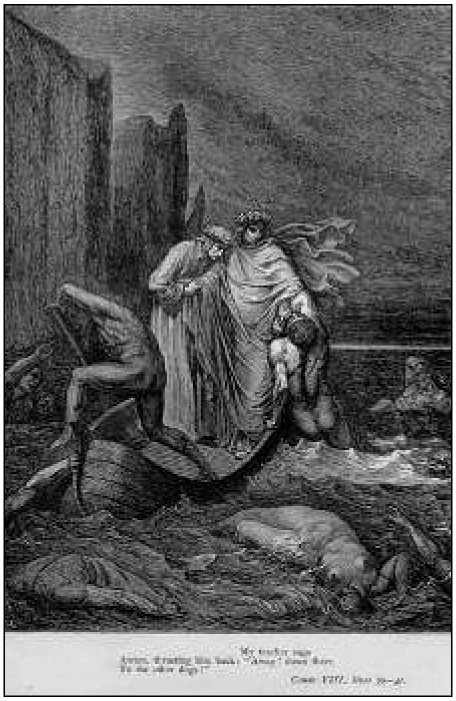


The engravings that follow are from the 1892 edition of the Divine Comedy illustrated by the engravings of Gustave Doré. All show our boatman, but the first is the figure most recognized.



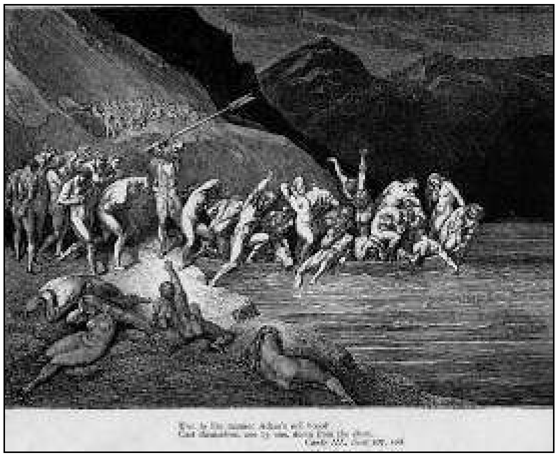
Charon

And lo! toward us in a bark
Comes on an old man hoary white with eld,
Crying, "Woe to you wicked spirits." (3:76-78)



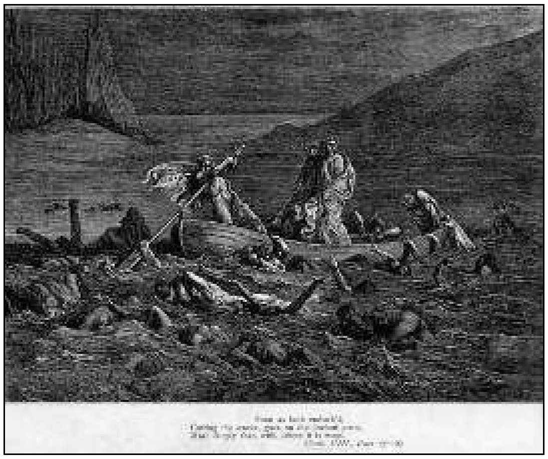
Virgil Pushes Filippo Argenti into the Styx

My teacher sage
Aware, thrusting him back, "Away! down there
To the' other dogs!" (8:39-41)



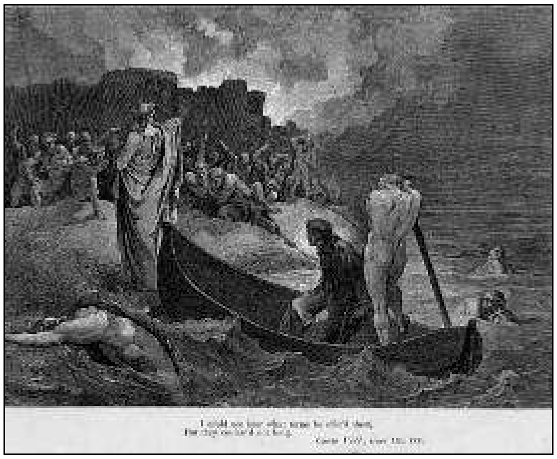
Charon Collects the Doomed Spirits

E'en in like manner Adam's evil brood
Cast themselves one by one down from the shore. (3:197-198)



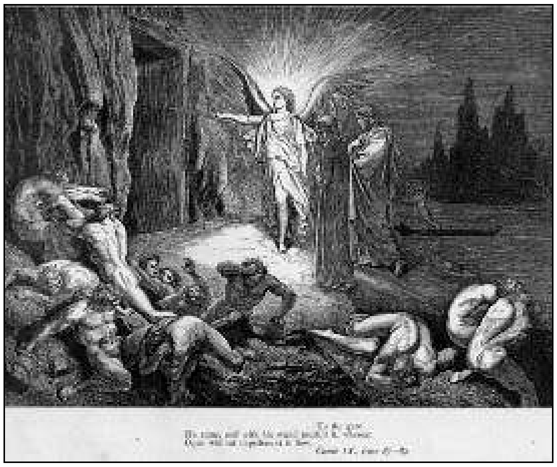
Across the Styx

Soon as both embark'd,
Cutting the waves, goes on the ancient prow,
More deeply than with others it is wont.
(8:27-29)



Outskirts of Dis

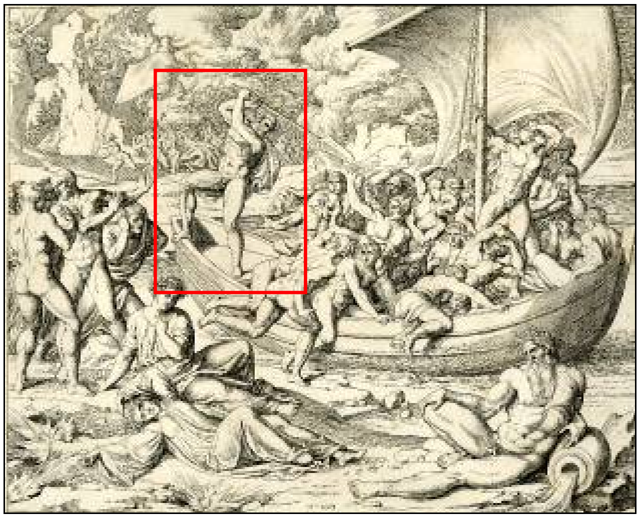
I could not hear what terms he offer'd them,
But they conferr'd not long. (8.110-111)



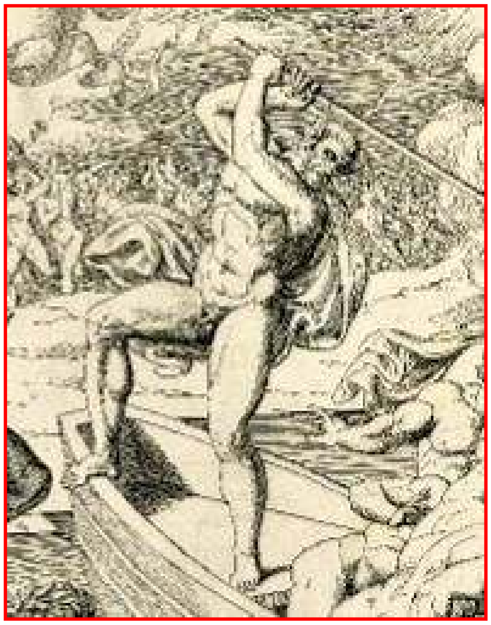
Opening the Gate

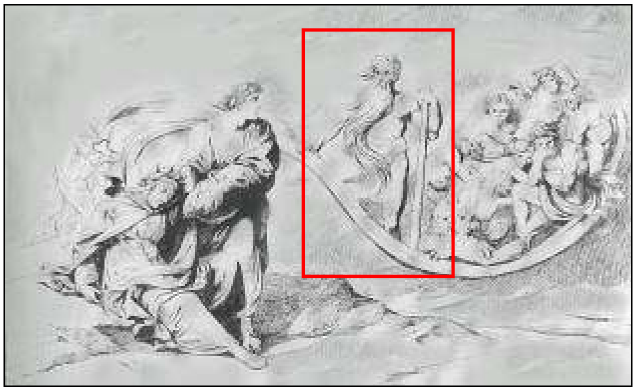
To the gate
He came, and with his wand touch'd it,
  whereat
Open without impediment it flew. (9:87-89)

Charon's craft is in the background

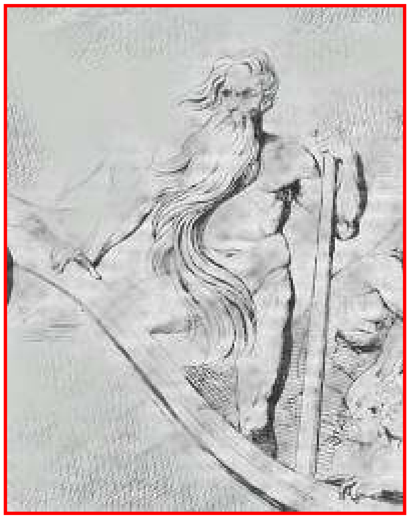


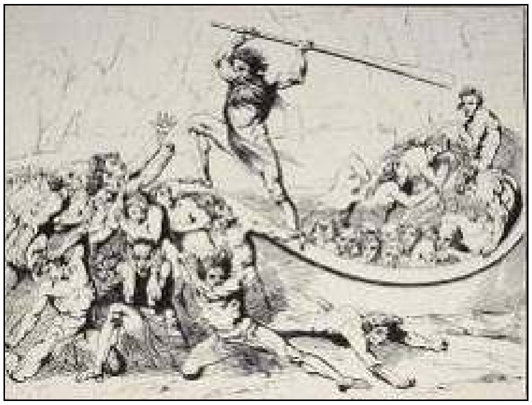
"Charon's Bark with Souls Crossing the Styx"
(1807-1808), Joseph Anton Koch



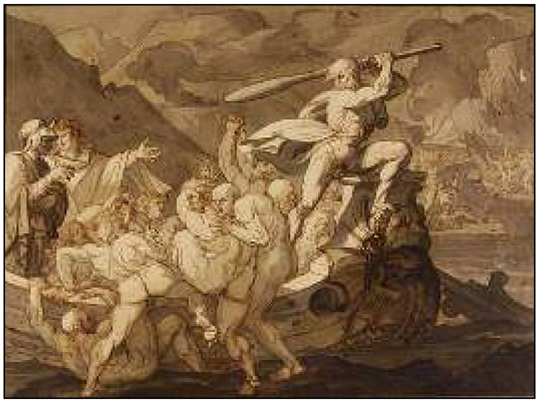


Sketch by Bartolomeo Pinelli (c. 1826). Note the remarkable beard.

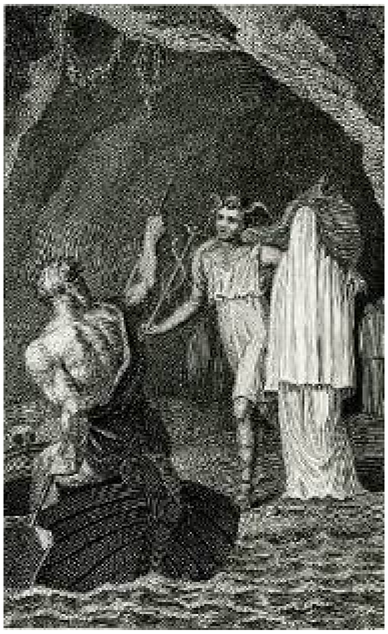




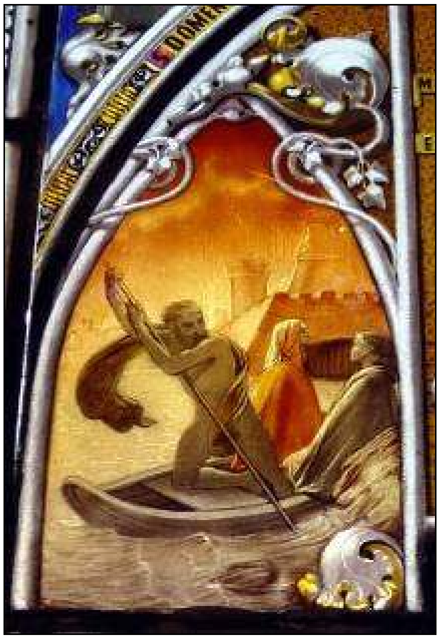
Another sketch by Bartolomeo Pinelli



Elie-Honoré Montagny (19th century)

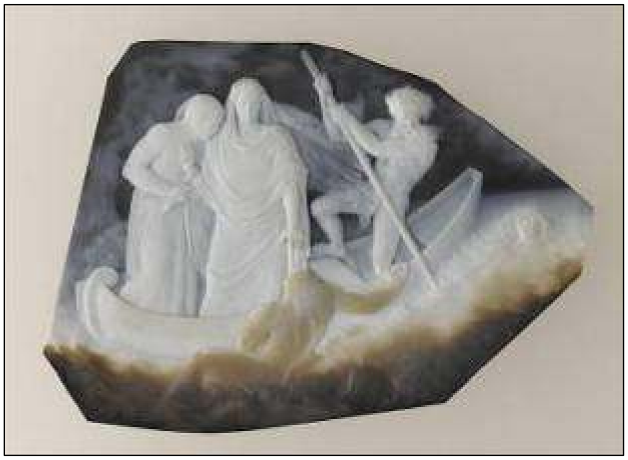


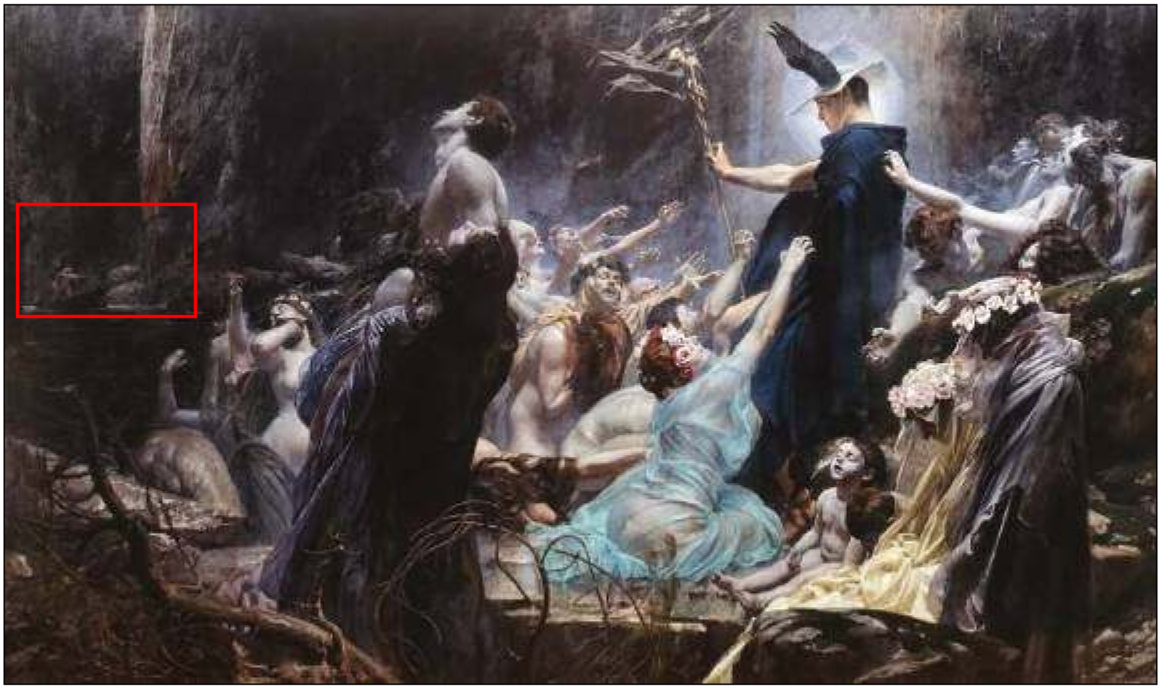
"Charon and Hermes" (1802-1833), Philippus Velyn

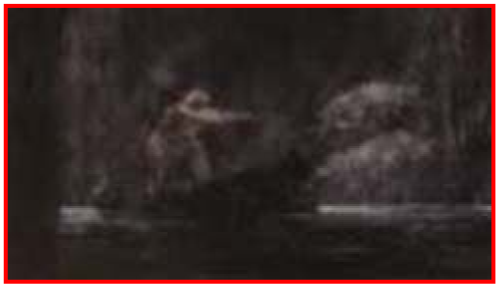


19th-century stained glass window, Poldi Pezzoli Museum, Milan

"Passage of the Styx with Dante and Virgil (1893)," Tonnelier Georges, sardonyx (a variation of onyx).



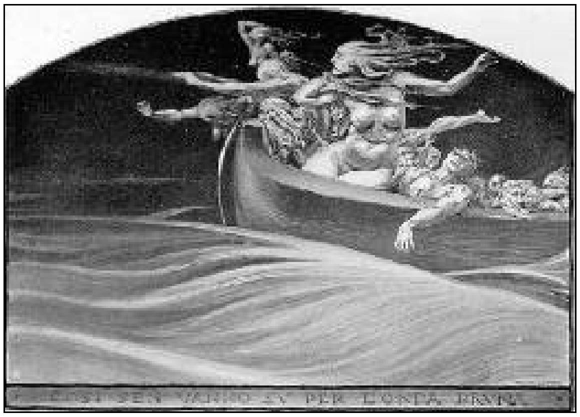




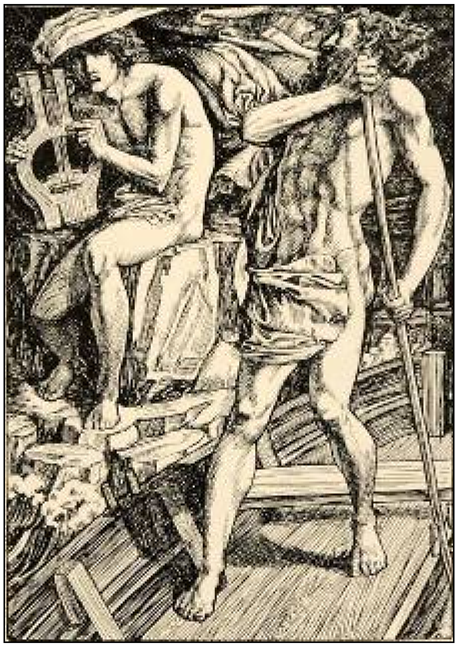
"Souls on the Banks of the Acheron" (1898) by Adolf Hiremy-Hirschl

Charon emerges from the darkness to row these souls to their final abode. The sight of his bark on the black waters strikes the multitude with terror.

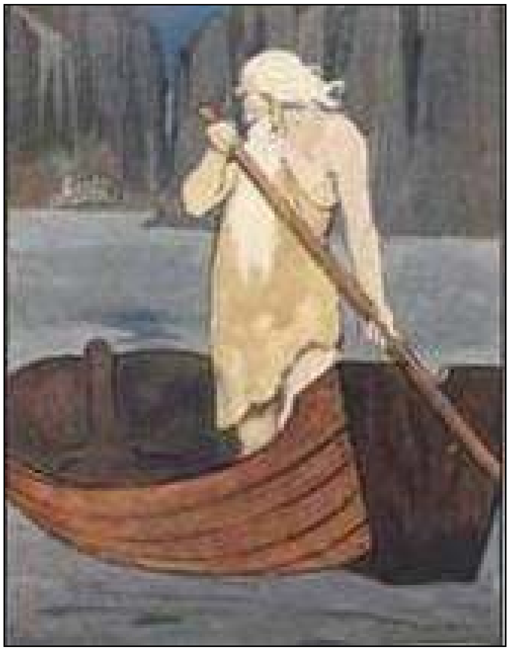
20th Century


COSI SEN VANNO SV PER L'ONDA BRVNA

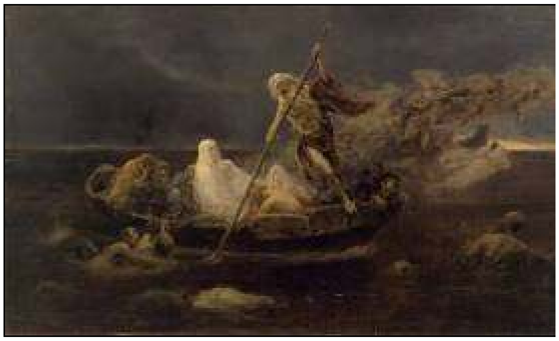
"Charon's Boat of Damned Souls Skimming across the Acheron" (1902), Alberto Martini



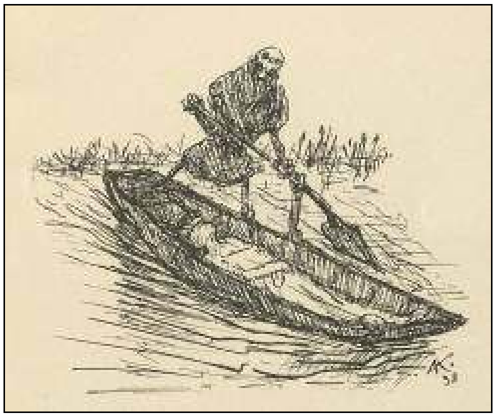
"Orpheus and the Boatman" 1907, drawing by A.J. Campbell**,** block by the Students of the London County Council School of Photo-Engraving and Lithography



"Charon Moving his Empty Boat toward a Distant Shore" (1909), Robert Traill Rose



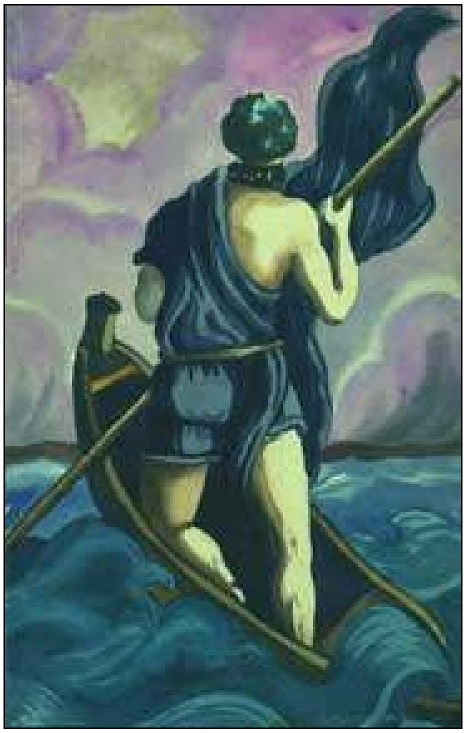
"The Boat of Charon" (1919) by Jose Benlliure y Gil is a fairly formulaic Greco-Roman rendition of the wearied oarsman and a ghost-like passenger.



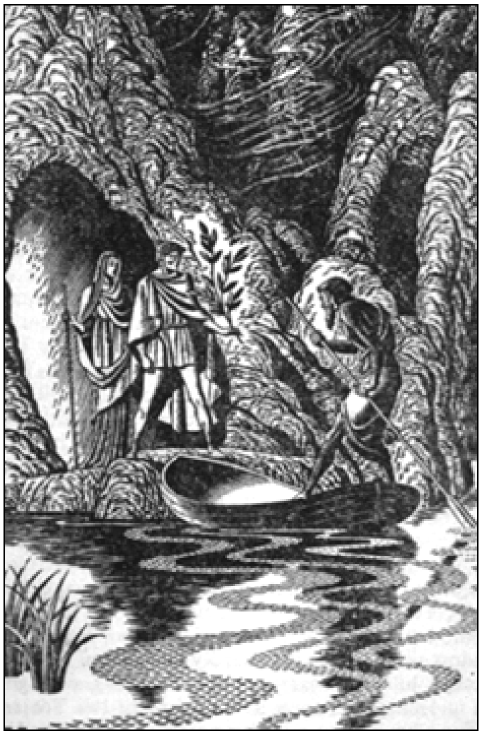
"A New Dance of Death" (1938) Alfred Kubin

The first Italian feature film, "L'Inferno" (1911), was a depiction of Dante's Divine Comedy.

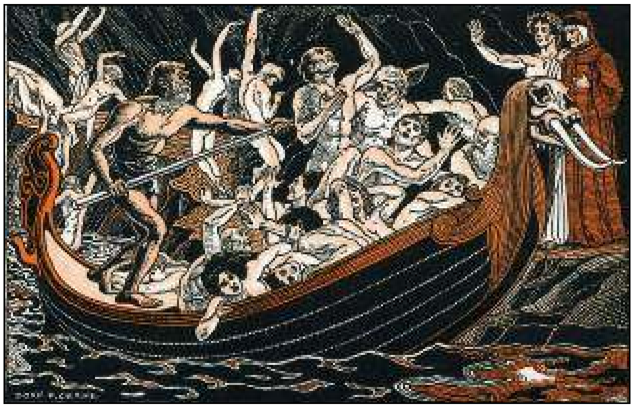
As Dante and Virgil approach the River Acheron, scores of naked bodies attempt to board Charon's craft, a scene staged as if it were a Doré etchings.



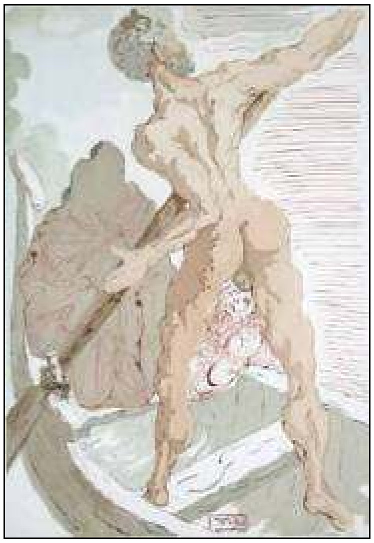
"Charon on the Styx" (1936),
Allen Bennett, a.k.a. Allen Pencovic



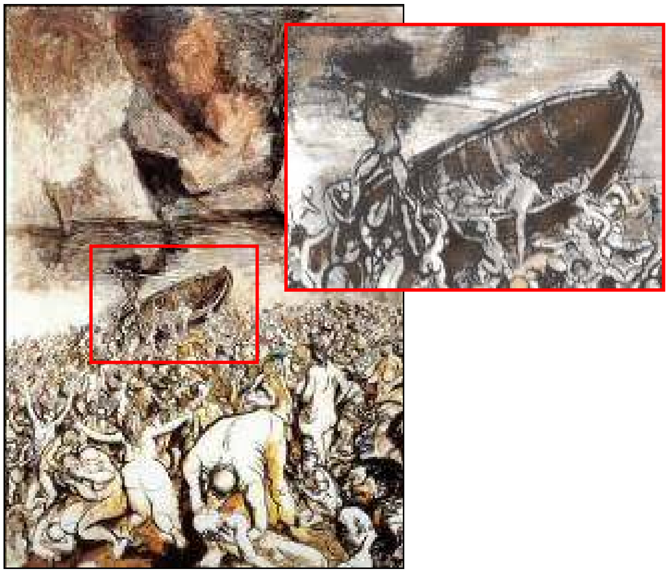
Mythology (1942), Edith Hamilton



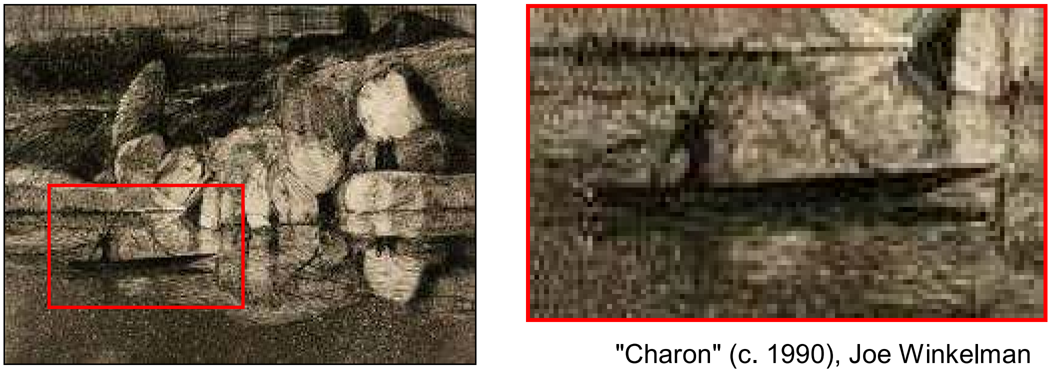
"A Dream of the Middle Ages," (1937), Donn Crane, My Book House 11



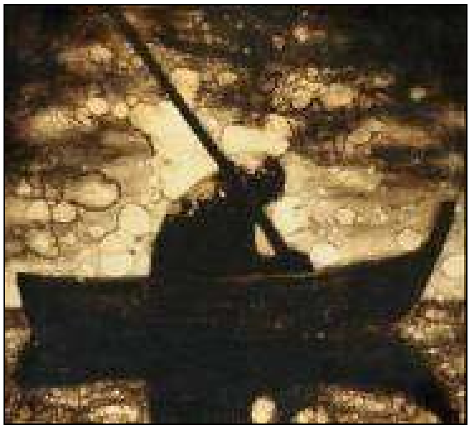
"Charon Crossing the Acheron," (1963), Salvador Dalí



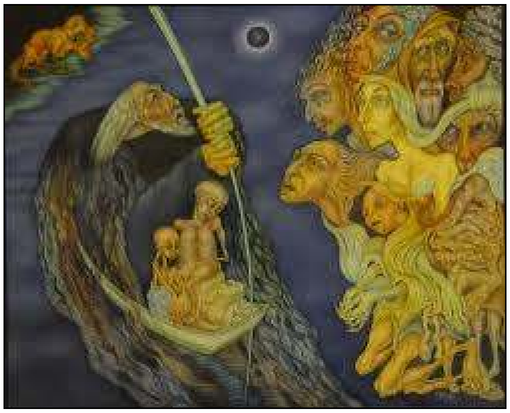
Of the works we've collected from both this century and the first decade of the next, Renato Guttuso's "Crossing the Acheron" (1970) is the only one with the smiting-oar stance.



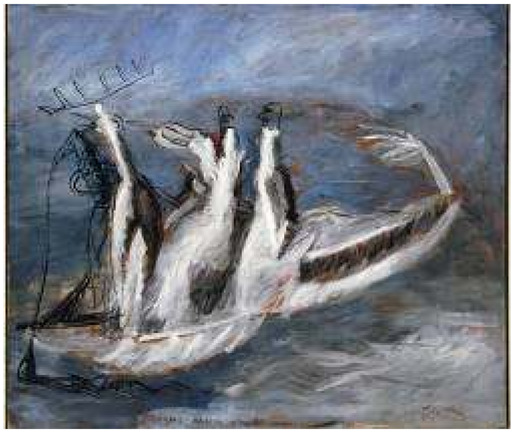
"Charon" (c. 1990), Joe Winkelman



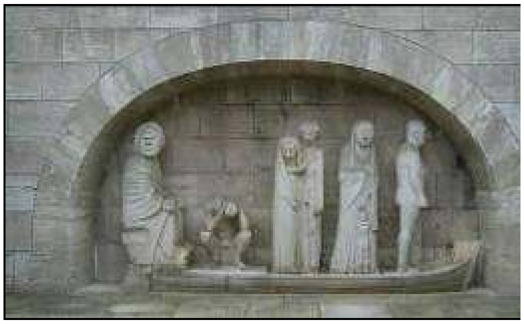
"Charon Sleeps" (1991), John Sokol



"The Crossing of the Styx" (1997), Eli Tiunine



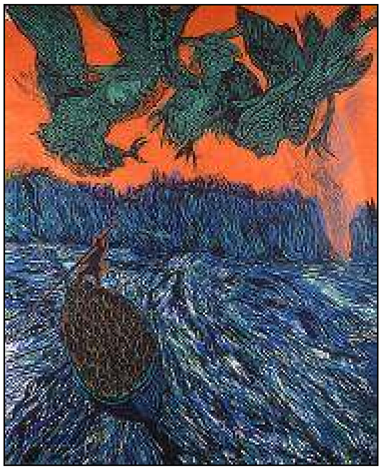
Gérard Garouste (1986)



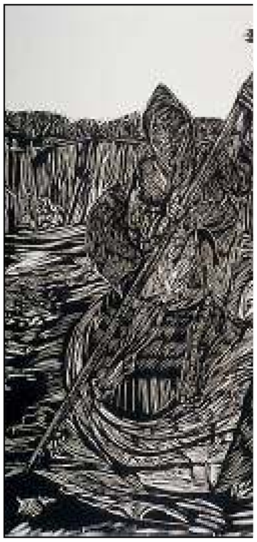
"Passage over the River Styx" (1952), a monument by Gerhard Marcks erected at the site of the Hamburg firestorm of August 3, 1943.

21st Century

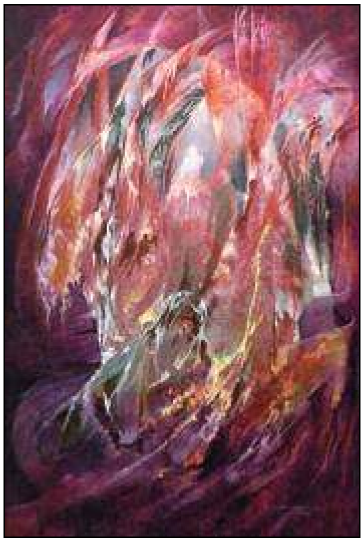
While it's far too early to predict Charon's depiction in the century upon us, we have indications.



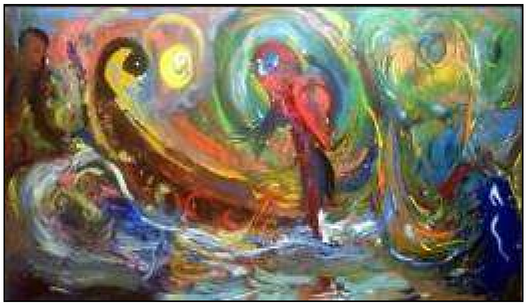
Donald Axleroad



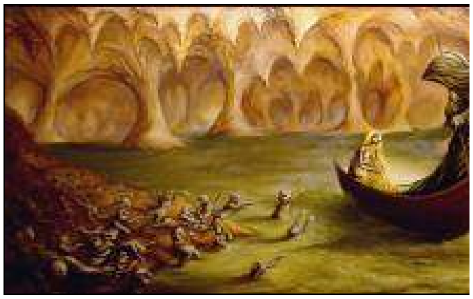
Donald Axleroad



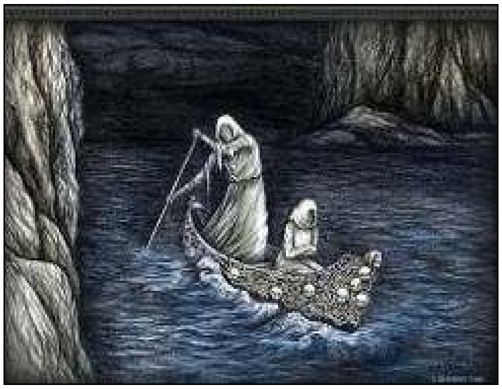
E. Thor Carlson



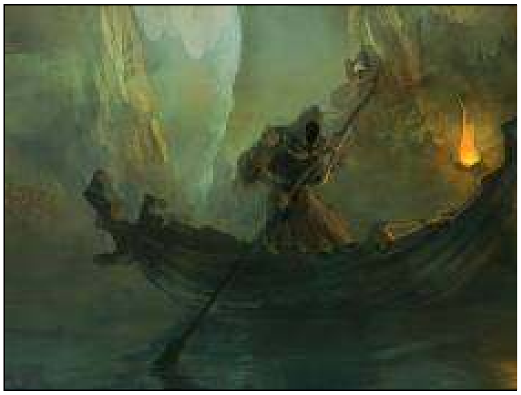
Detlef Hahn and Jamie Boyd



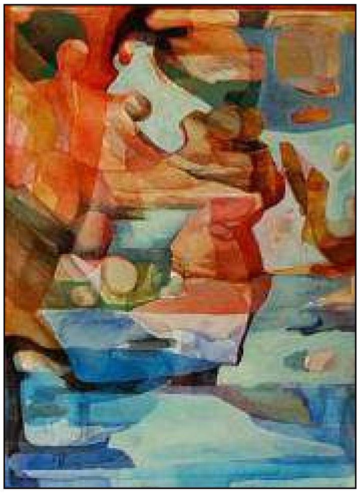
Bradley Platz



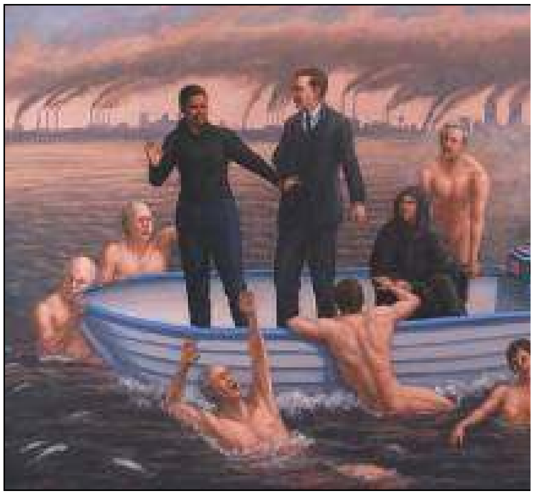
Sherrie Thai



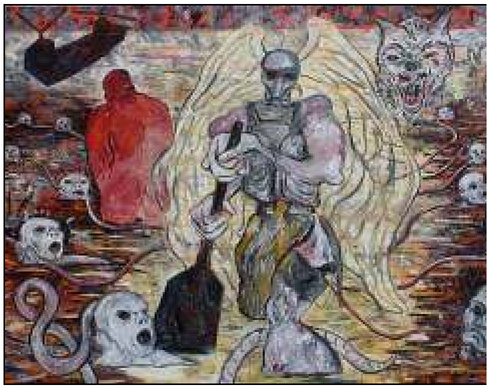
Nick Skochev



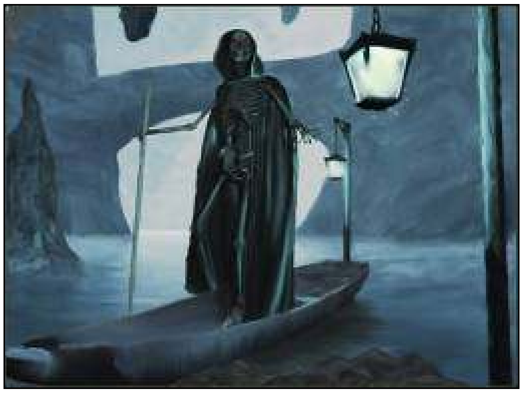
Paco Garcia



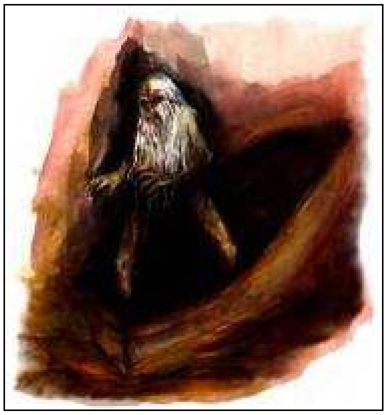
Sandra Yagi



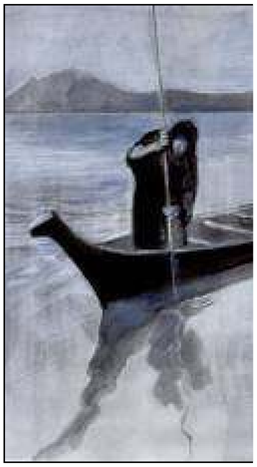
George Gittoes



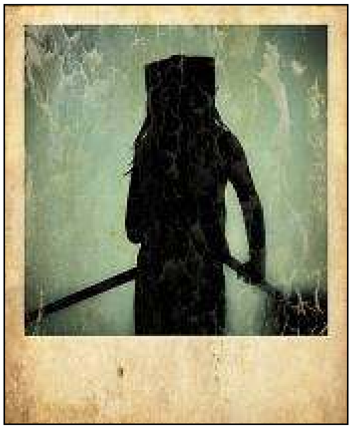
Martine Davies



Suloni Robertson

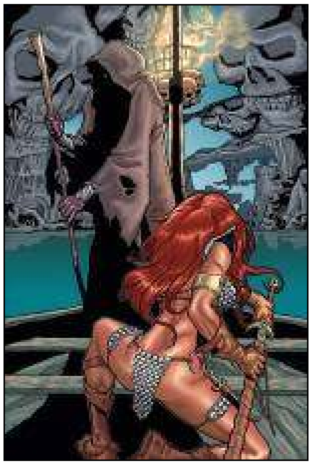


Adam Shaw



Luke Olsen

Robert Talpin

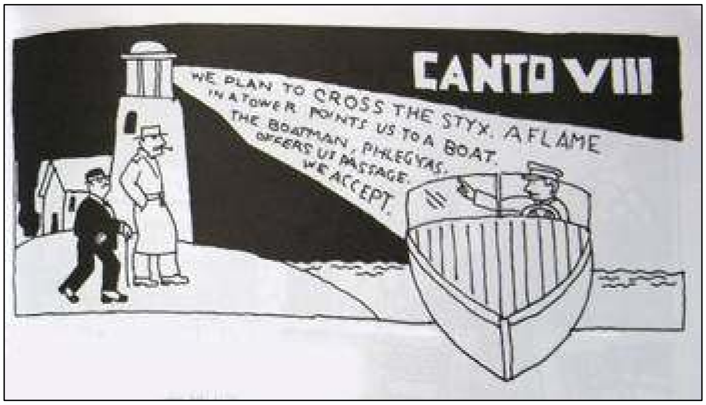


Red Sonja #30, January 2008, the "She-Devil with a Sword" on the River Styx

A Legos model doesn't qualify as a portrait, of course, but it seems worth noting.

And a lasting character is our protagonist is, as evidenced in Seymour Chwast's 2010 illustrated novel adaptation of the Divine Comedy.

> *We plan to cross the Styx. A flame in a tower points us to a boat. The boatman, Phlegyas, offers us passage. We accept*


CANTO VIII
WE PLAN TO CROSS THE STYX. A FLAME IN A TOWER POINTS US TO A BOAT. THE BOATMAN, PHLEGYAS, OFFERS US PASSAGE. WE ACCEPT.

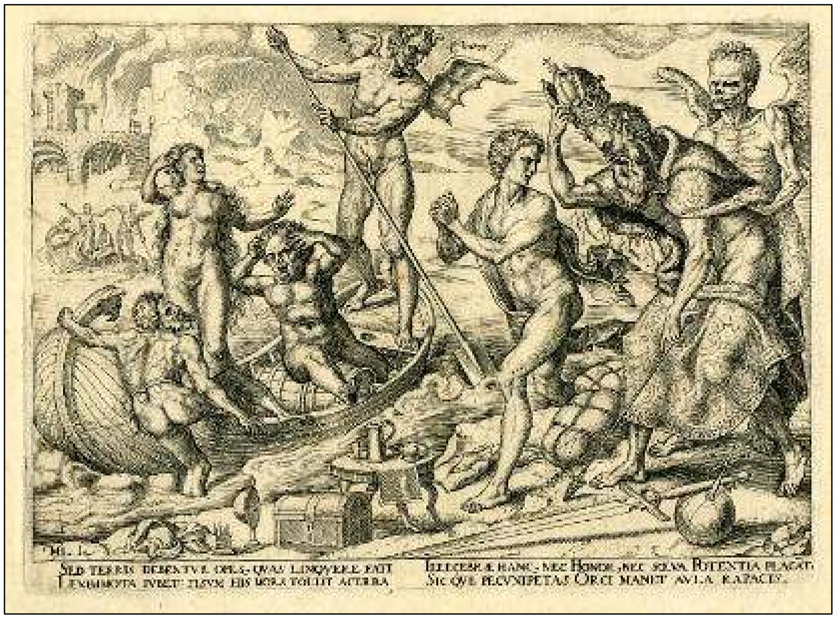
And we've still more portraits of our boatman in the chapter to follow, graphics in which our character is employed to convey a message more particular to the day.

CHAPTER 34
CHARONIC POLITICAL CARTOONARY

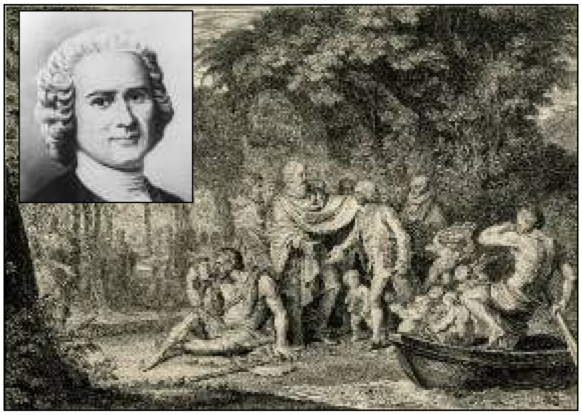
Cartoonists have long portrayed Charon ferrying the well-known and wealthy to their just desserts. The ancient boatman is sometimes drawn as the muscular Greek sailor, sometimes as the wearied laborer, sometimes as the ferocious demon, all incarnations from the art world. Charon ferries some clients to what looks to be an Elysian Field afterlife, but more often he's rowing them toward Hell. Our versatile boatman serves whatever purpose is assigned him.

Holland

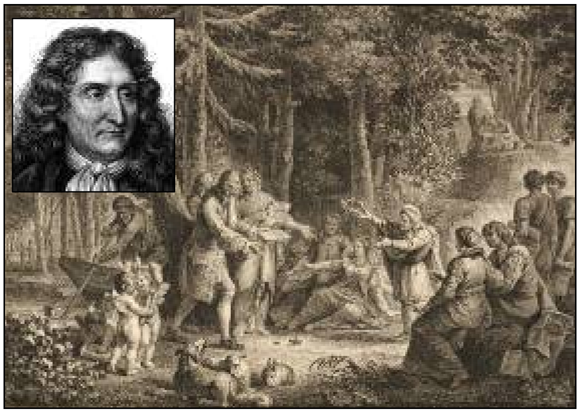
In "The Wretchedness of Wealth" (1563) after Maarten van Heemskerck, Death ushers a bejeweled king towards Charon's boat. Money is of no avail in the dying hour.



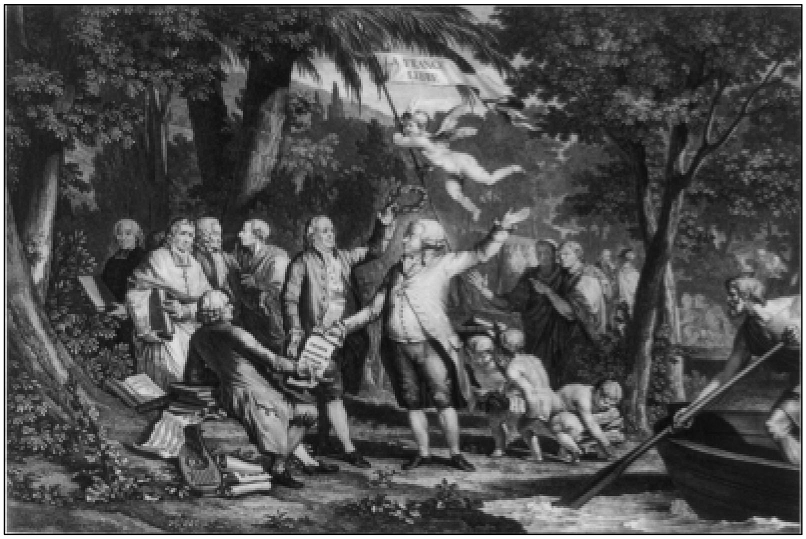
France



"Arrival of J.J. Rousseau at the Elysian Fields" (1782)

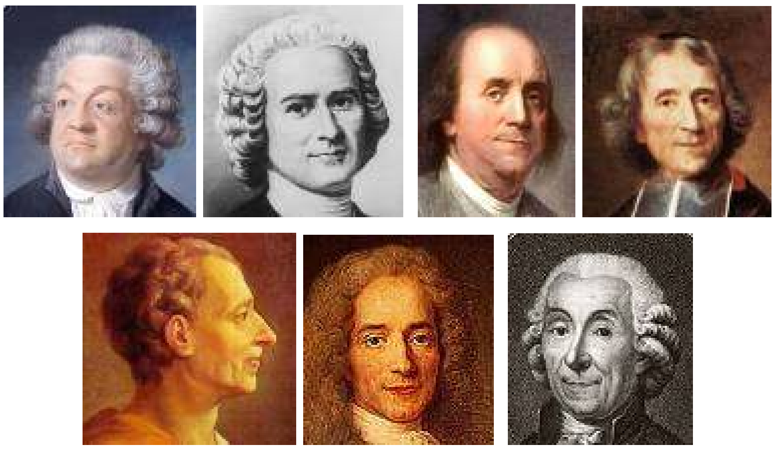


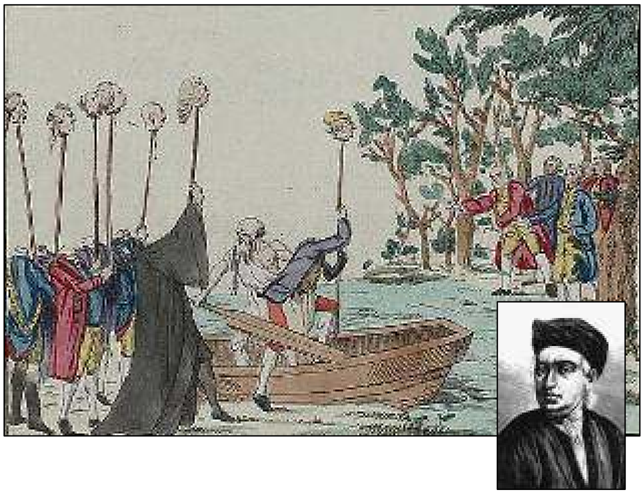
"Coronation of the Fountain at Elysian Fields" (1785). Poet Jean de La Fontaine is welcomed to Elysium. Virgil and Pliny converse next to Petrarch and Laura. Charon is behind the tree.



"Mirabeau arrives aux Champs Élisées" (1791). Mirabeau, at the center, arrives at the Champs Élisées where he hands a copy of the French Constitution to Rousseau while Benjamin Franklin bestows a wreath. On the left, Fénelon, Montesquieu, Voltaire and Mably come to greet the recent arrival. On the right, Demosthenes talks with Cicero. Charon pushes his boat from shore.

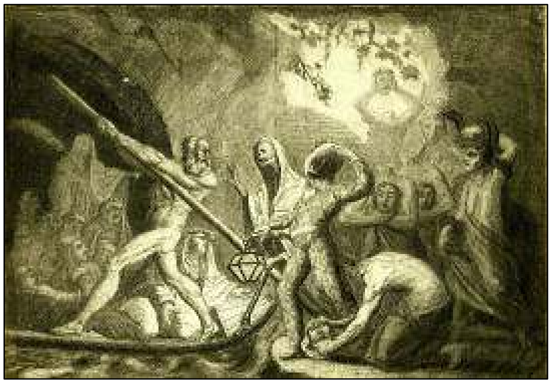
The aforementioned,

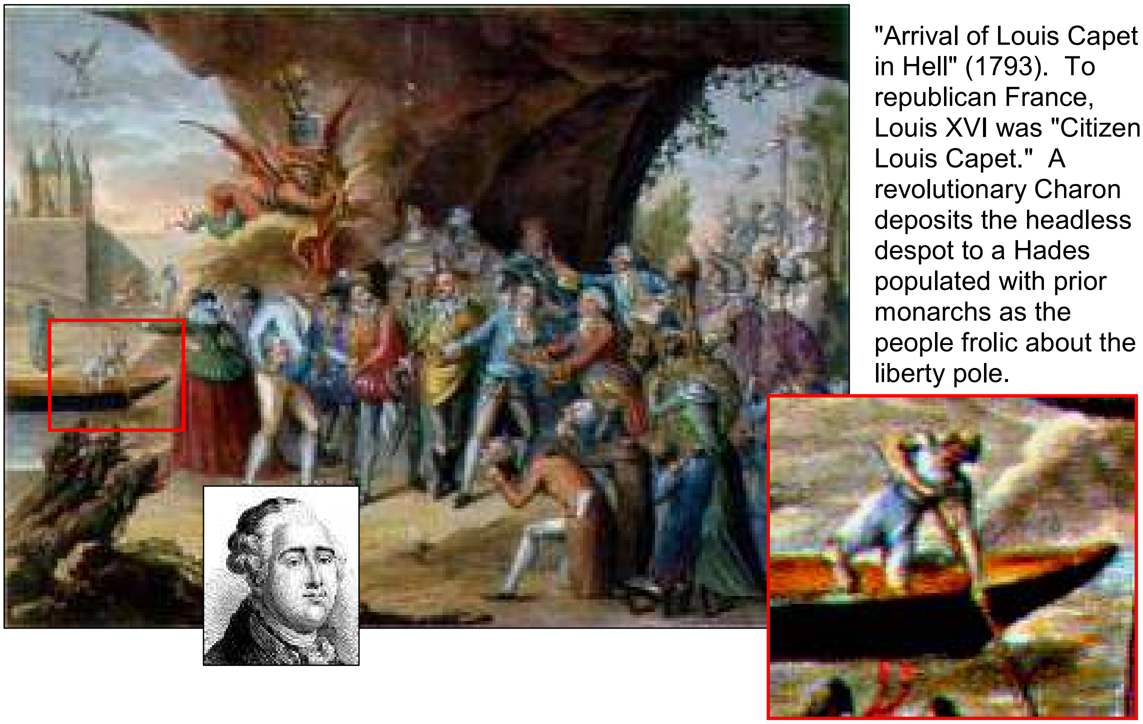




In this 1789 cartoon, Charon accepts the baker Remy François, mistakenly beheaded in the aristocratic fury, into his boat while rejecting officials and guards who carry their severed heads atop pikes. On the opposite shore, the Elysian Fields, Jean Calas and others welcome the baker.

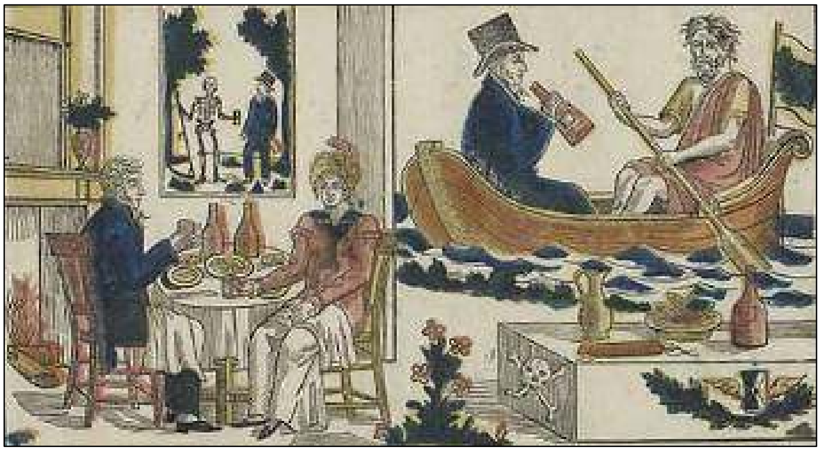
"Avis aux Aristocrates" (1790), Satire against the Aristocracy. Charon refuses to ferry a crowd of dead aristocrats.





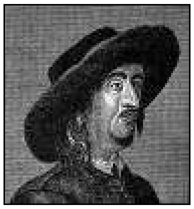
"Arrival of Louis Capet in Hell" (1793). To republican France, Louis XVI was "Citizen Louis Capet." A revolutionary Charon deposits the headless despot to a Hades populated with prior monarchs as the people frolic about the liberty pole.

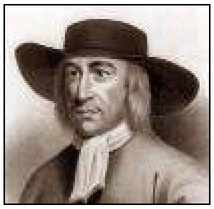
In post-revolutionary France, Louis Abadie's "La Barque a Caron" (1825) warns that Charon awaits the drunkard.

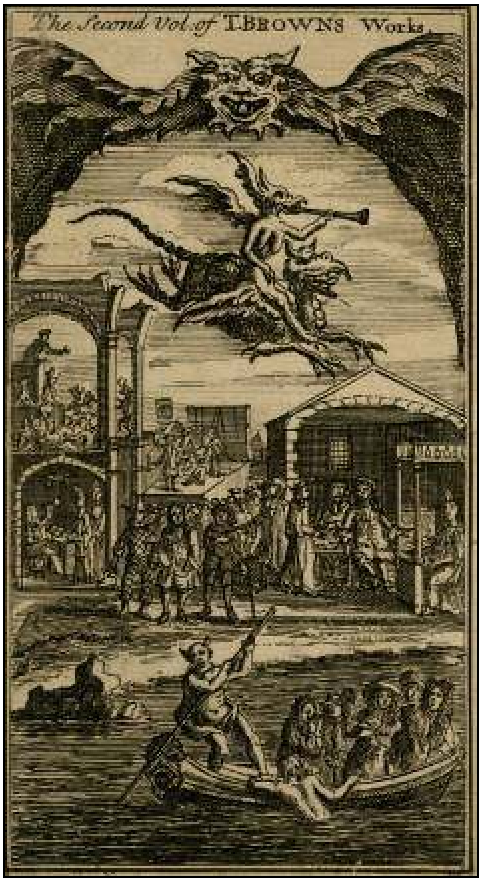


Great Britain

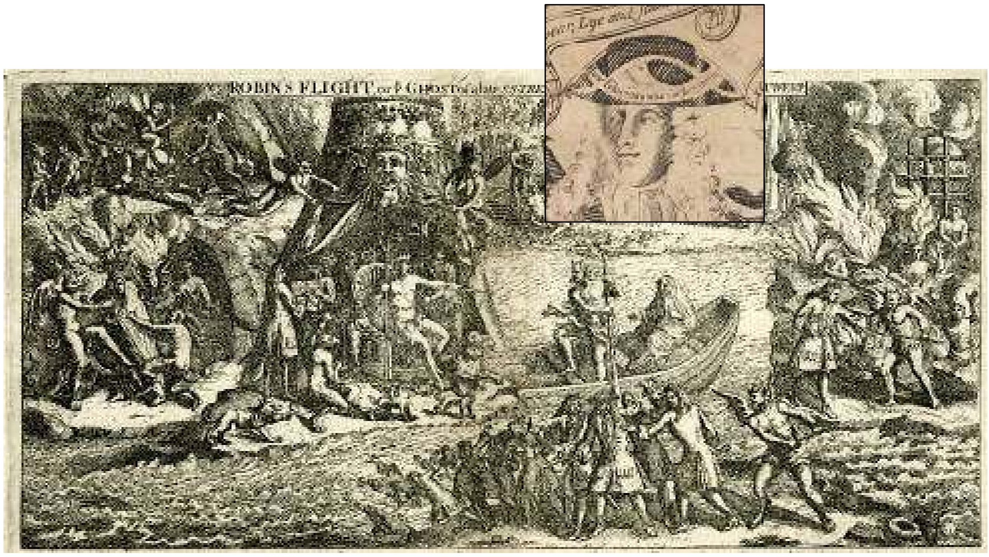
To the right, the frontispiece to The Works of Mr. Thomas Brown (1715), showing Charon ferrying a group of gentlemen across the Styx. On the bank stand the author and the recently dead comic actors Joe Haines and James Nokes. The actor Antony Leigh (also recently dead) preaches from a ruined church, while an astrologer speaks to well-dressed women. The Quakers James Nayler and George Fox, pictured below, approach.



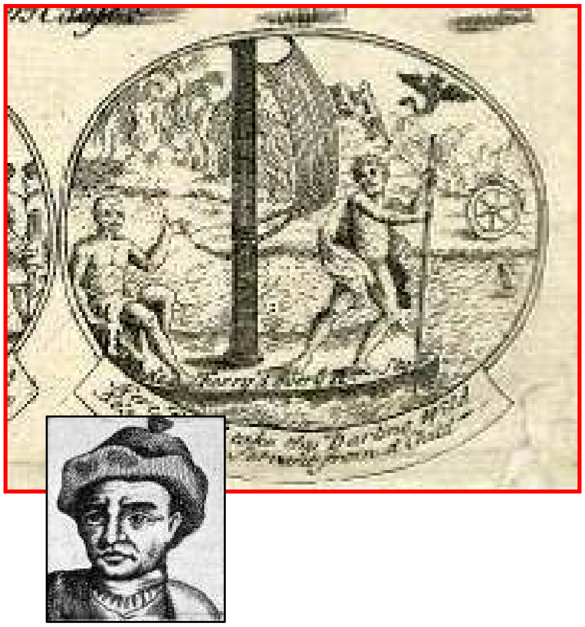


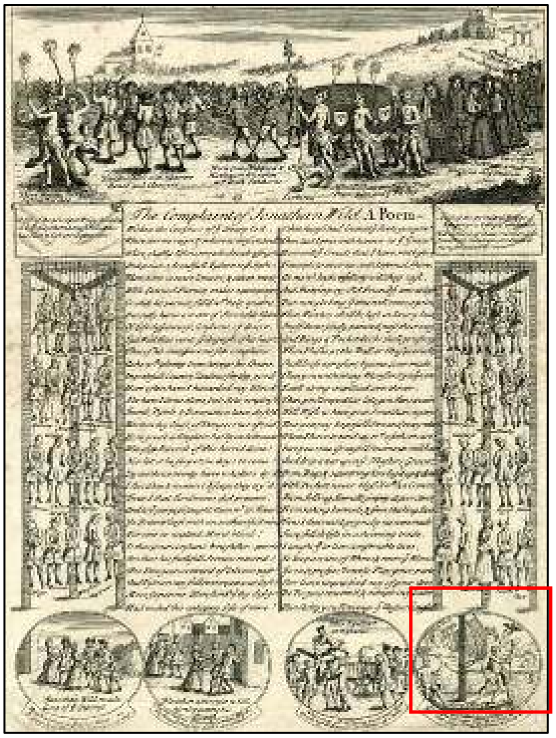

The Second Vol. of T.BROWNS Works.

"Robin's Flight, or Ye Ghost of a Late Treasurer of the South Sea Company Ferry'd into Hell" (1721). Absconder Robert Knight -- the facial from another cartoon -- is led by the Devil to the River Styx, refused entry into Elysian Fields and turned away from Purgatory. As a shrouded ghost, Knight is ferried by Charon to Hell where Pluto, attended by monsters and a diabolic accountant, await. Knight is then dragged into Hell by tormenting devils and forced to surrender his ill acquired wealth.

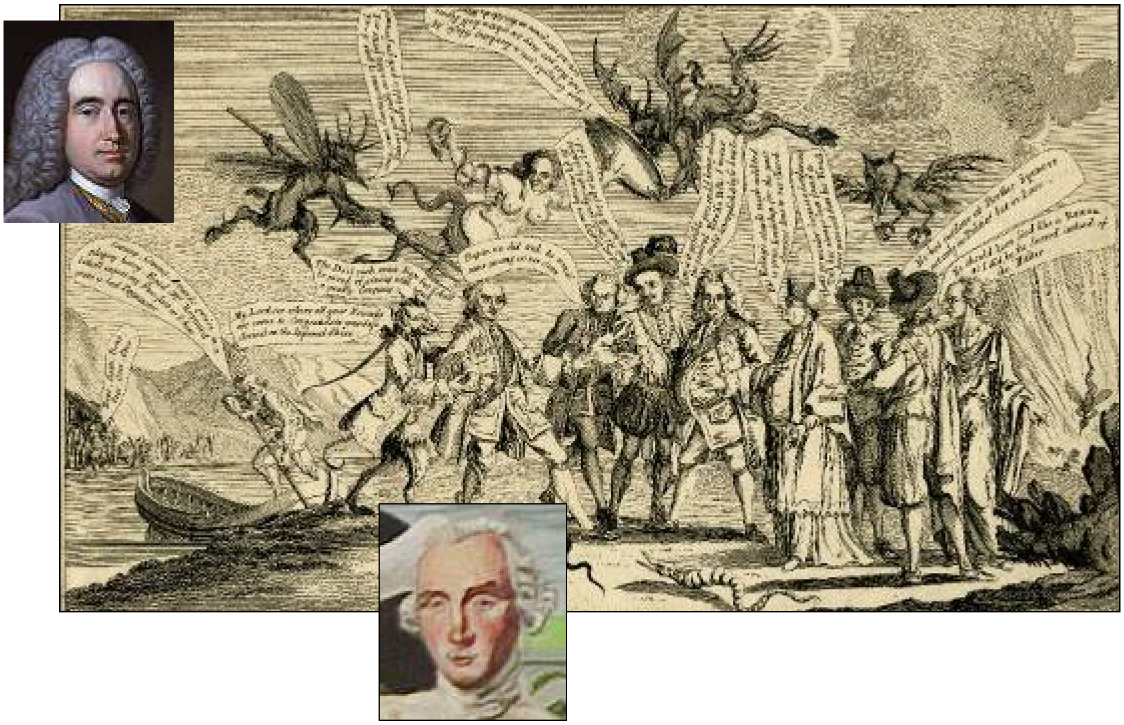

ROBIN'S FLIGHT or Ye GHOST of a late

"The Funeral Procession of the Celebrated Mr. Jonathan Wild, Thief-Taker General of Great Britain & Ireland" (c. 1725) celebrates the execution of the criminal Jonathan Wild. The mourners are led by Beelzebub as Wild is ferried to Hell by our boatman.

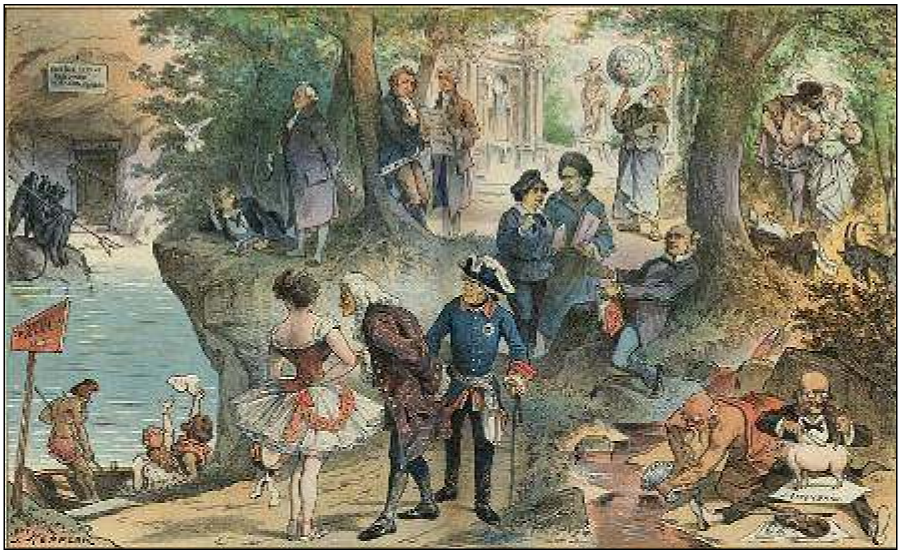



The Complaint of Jonathan Wild. A Poem

In "Sawney Below Stairs" (1763), Lord Bute arrives on the shore of Hades where an elegantly-dressed devil introduces him to earlier politicians while a snake ascends Bute's leg. A devil flying above holds a mirror, allusion to Bute's vanity. Charon demands his fare in advance, as Bute's crony Henry Fox is "a bad Paymaster"

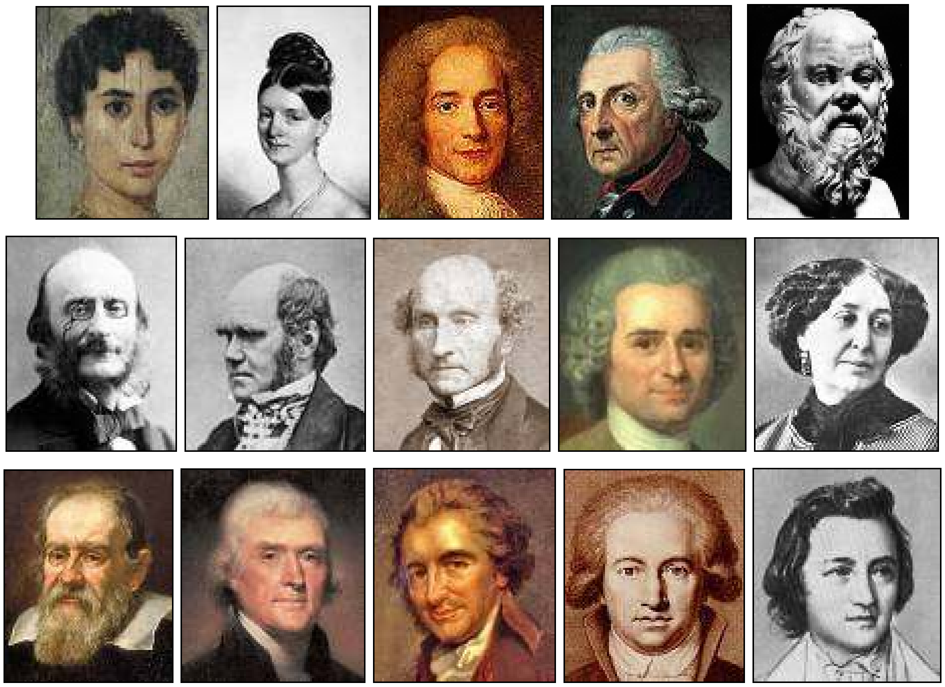


"Sheol, Puck, May 27, 1885, reverses Charon's route.

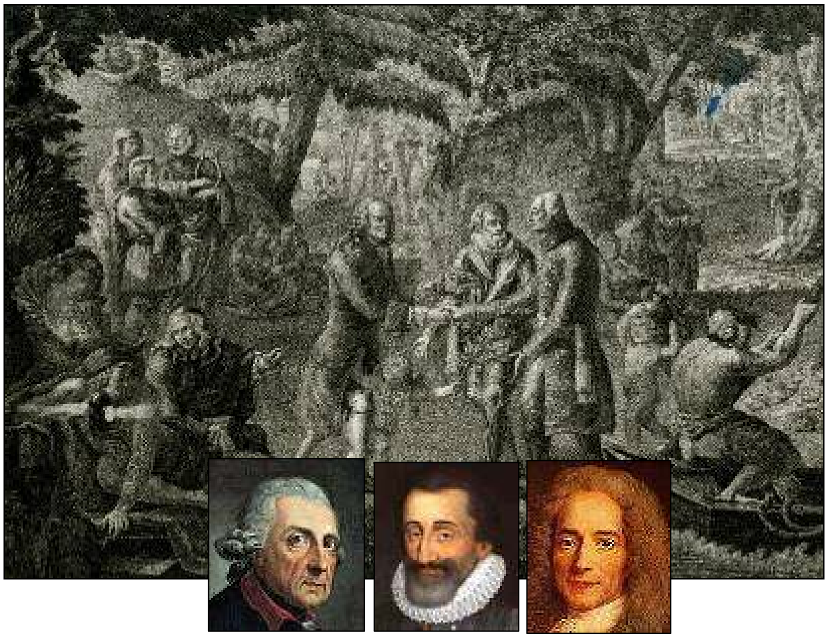


> *According to the new version of the Old Testament, many respectable people who have been writhing in the old fashioned Hell will have to be transferred to the pleasant watering-place known as "Sheol." This is Puck's notion of the evolution of Hell to Sheol.*

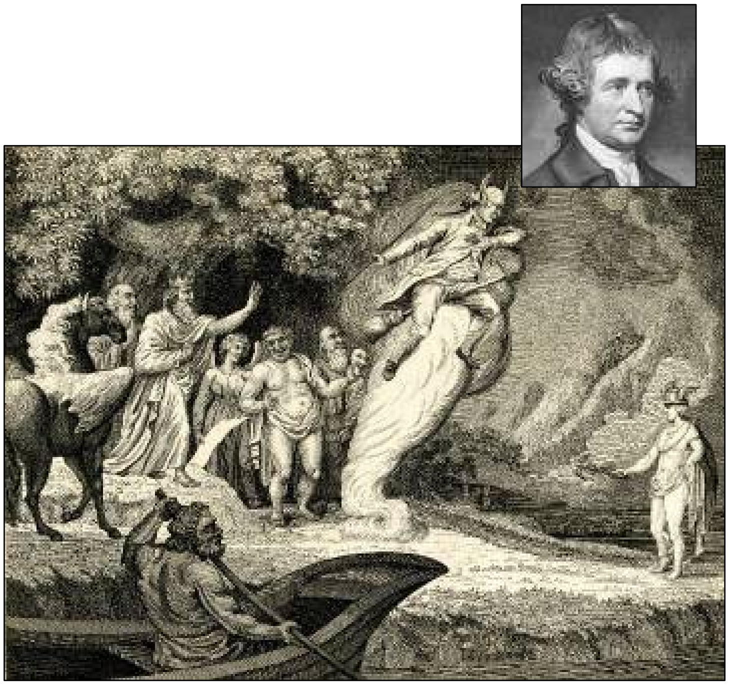
To the figure's left, the dejected Devil sits beneath a sign, "This Business is Removed to Sheol, Opposite." Among those ferried to Sheol by Charon are the philosopher Hypatia, Fanny Elssler, Voltaire, Frederick the Great, Socrates, Offenbach, Darwin, J.S. Mill, Rousseau, George Sand, Galileo, Jefferson, Thomas Paine, Goethe and Heinrich Heine.



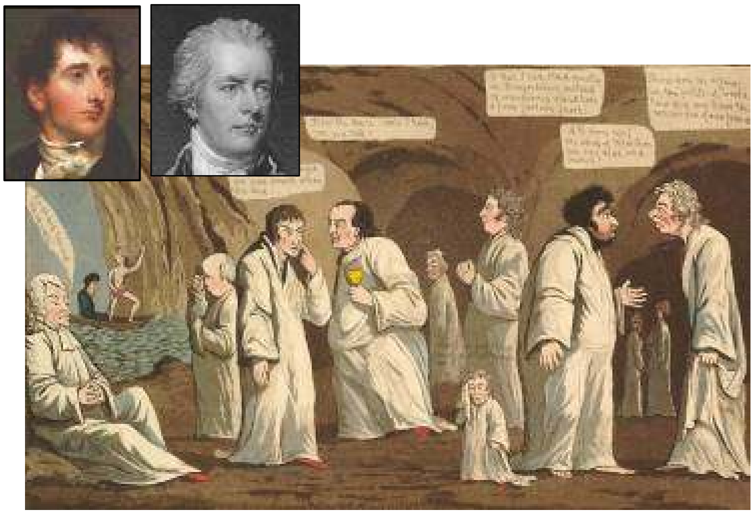
"The King of Prussia arriving in Elysium is reconciled with Voltaire by Henry IV" (c. 1800). Charon's to the right.



Frontispiece to The Wonderful Flights of Edmund the Rhapsodist, into the Sublime and Beautiful Regions of Fancy, Fiction, Extravagance, and Absurdity (1791). Charon sits in his ferryboat as Edmund Burke, with ass's ears, sits astride a broomstick and is carried upwards on a cloud rising from ground containing the slaughtered victims to the divine Right of Kings and the sanguinary Principles of the Priesthood of all Ages.

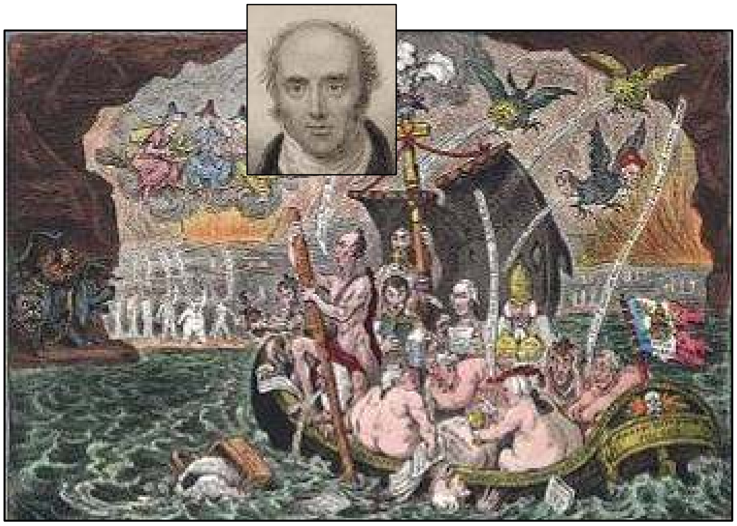


"Shades of Opposition; or, More Ghosts" (1798). Members of the Opposition converse in Hades while William Pitt, as Charon, ferries Francis Burdett towards his companions. In the distance are two lank figures, perhaps United Irishmen.

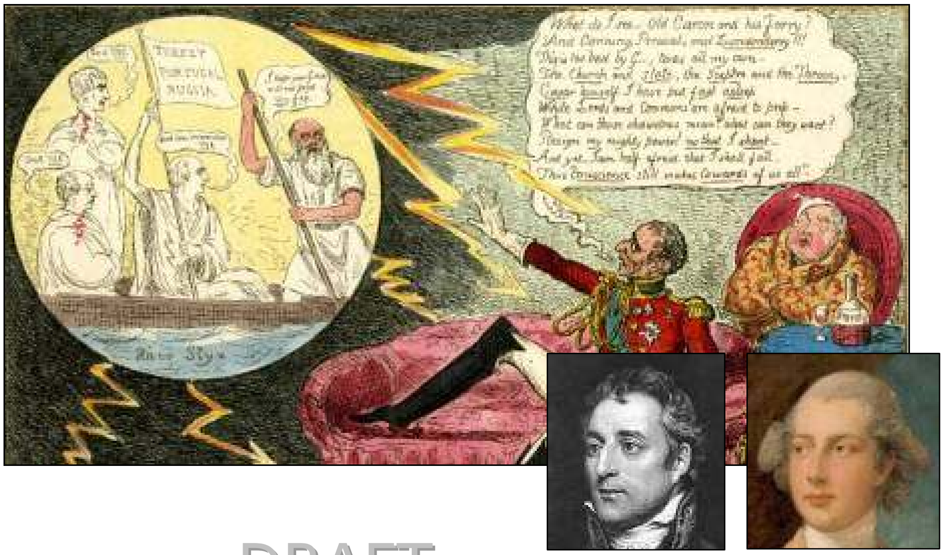


"In Charon's Boat" (1807). The fallen Wig leader Earl Grey is Charon. Grey, however, was to return to politics as Prime Minister, reform the government and abolish slavery throughout the Empire.

In addition, this particular Charon provided his name to a familiar blend of tea.



In "A Vision of Judgment" (1829), a haggard Wellington starts up from a sofa, horrified at a vision of Charon's boat with banner "Turkey, Portugal, Russia."



Wellington:

> *What do I see -- Old Caron and his ferry?*
> *And Canning, Percival, and Londonderry?*
> *This is too bad by G-- 'twas all my own*
> *The Church and State, the Scepter and the Throne,*
> *Caesar himself I have put fast asleep*
> *While Lords and Commons are afraid to peep.*
> *What can those shadows mean? What can they want?*
> *Resign my mighty power! No that I shan't.*
> *And yet I am half afraid that I shall fall,*
> *Thus "Conscience still makes Cowards of us all" -- ['Hamlet', III. i]*

King George IV dozes in his armchair, a bottle of brandy beside him.

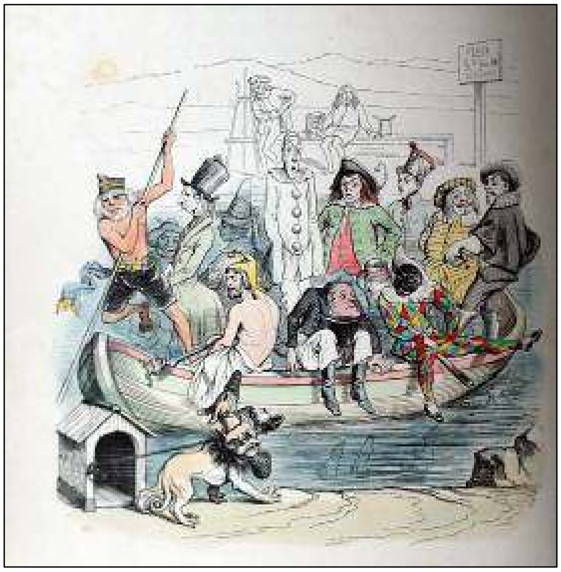
Charon:

> *I hope your Grace will not forget my fee.*

J.J. Grandville was a caricaturist later recognized as a grandfather of Surrealism. Un Autre Monde (1844) describes a parallel world, a thinly-veiled parody of our own. "La Barque a Caron" is one of many illustrations from the work

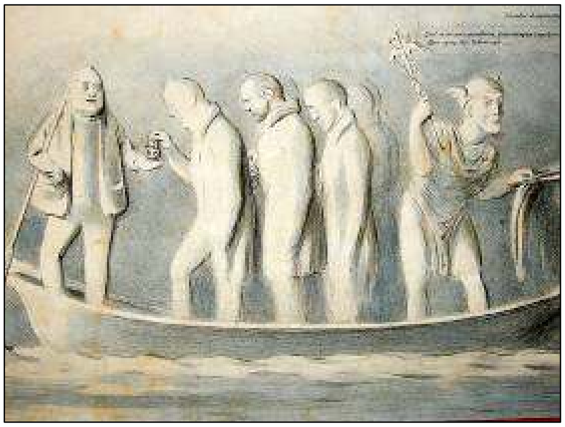
> *Portitor has horrendus aquas and flumina*
> *servat, terribili squalore Charon*
>
> *Ferryman of these horrible water and streams,*
> *Charon, in his terrible squalor.*

We're unsure of identities, caricatures of the day's well-known personages.

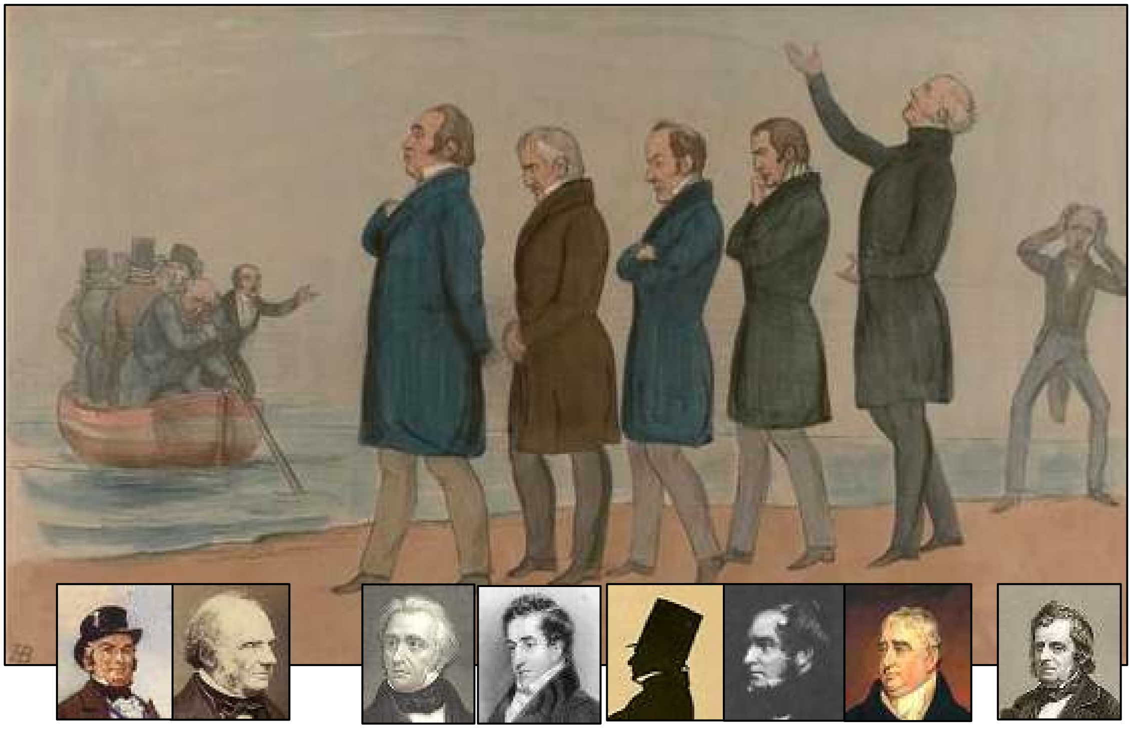


Two drawings by John Doyle for his series Political Sketches.

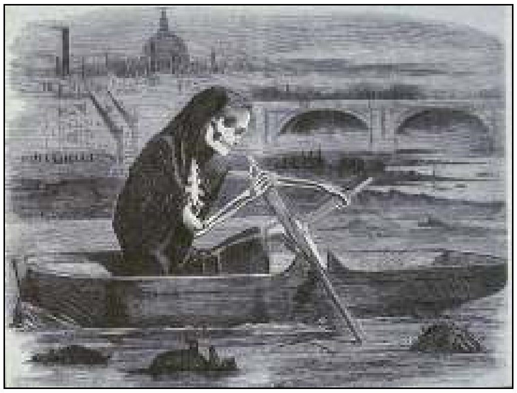
"Unhappy ghosts crossing the Styx" (1834).



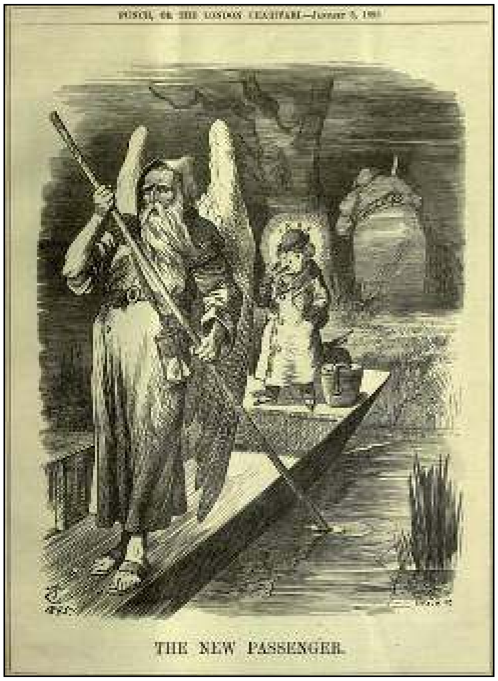
"Unhappy ghosts wandering on the banks of Styx, while Charon in his boat ferries over the elect to the Elysian Fields" (1847)



The unhappy ghosts of Thomas Macaulay, Sir John Hobhouse, Benjamin Hawes, Thomas Wyse and Charles Fox walk disconsolately on the banks of the Styx, followed by John Roebuck, tearing his hair, while Charon (John Bull, symbolic England) moves off for Elysium with John Russell and his colleagues. The silhouette of Hawes was made on Brighton Pier

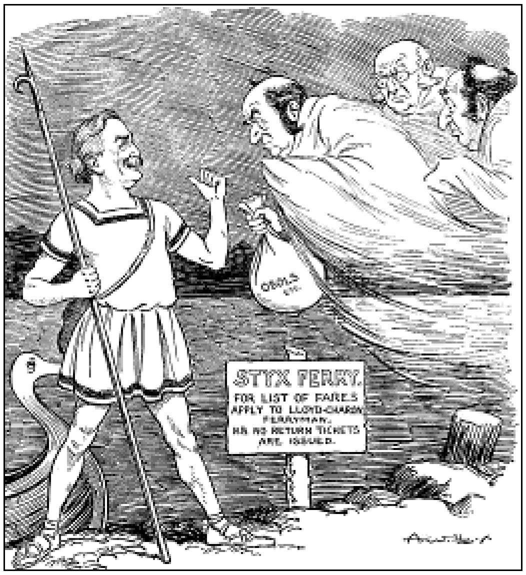


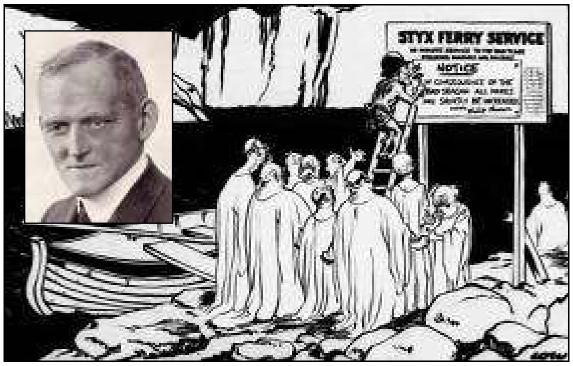
Early environmental journalism: "Silent Highway Man" from an 1858 issue of Punch.


PUNCH, OR THE LONDON CHARIVARI.—January 5, 1865
THE NEW PASSENGER.

Punch, January 5, 1865, welcomes "The New Passenger."

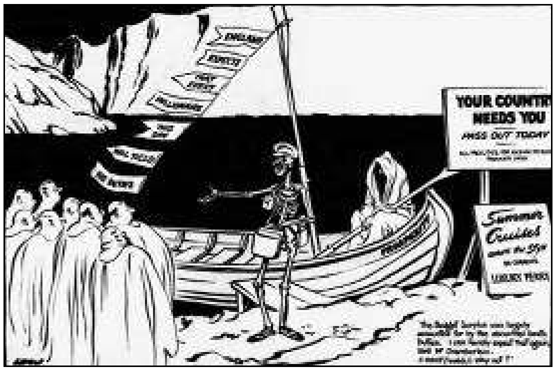
Lloyd George Charon to Plutocratic Shades, "Your fares will cost you more!" -- Punch, May 13, 1914


OBOLS ETC.
STYX FERRY.
FOR LIST OF FARES APPLY TO LLOYD-CHARON FERRYMAN.
N.B. NO RETURN TICKETS ARE ISSUED.


STYX FERRY SERVICE
NOTICE

"Threatened increase in the high cost of dying. Mr. Philip Snowden's comments on the unsatisfactory receipts of Death Duties are held to foreshadow an increase in these in the next Budget" (1930).

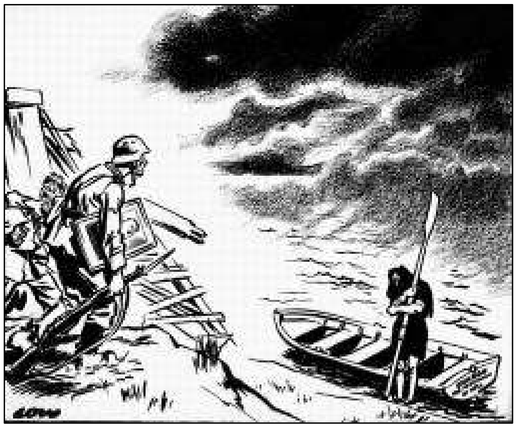
> *Styx Ferry Service. 10 minutes service to the bad place including Sundays and holidays. Notice In consequence of the bad season all fares may shortly be increased. Signed, Philip Charon.*


YOUR COUNTR
NEEDS YOU
MISS OUT TODAY
Summer Cruises
LUXURY FERRY

"A Patriotic Appeal" (1934)

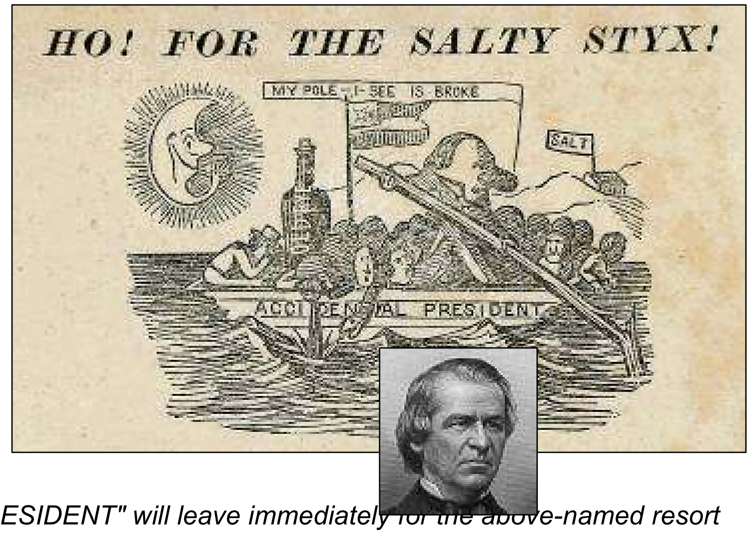
> *England Expects That Every Millionaire This Day Will Yield His Duties*
>
> *Summer Cruises across the Styx on Charon's Luxury Ferry*

"Seine Crossing" (1944)



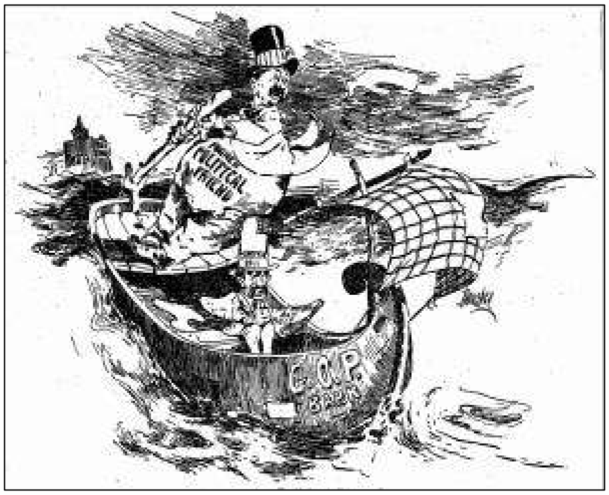
United States

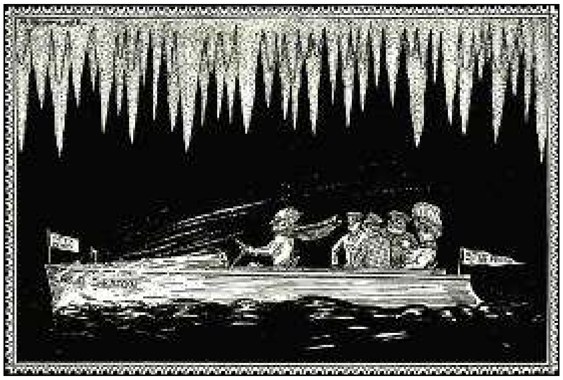
The 1865 broadside, “Ho! For the Salty Styx!” attacks Andrew Johnson’s ascension to the presidency upon the assassination of Abraham Lincoln. Johnson, as Charon, pilots the boat “Accidental President,” with the text beneath.


HO! FOR THE SALTY STYX!
MY POLE—I SEE IS BROKE
SALT
ACCIDENTAL PRESIDENT

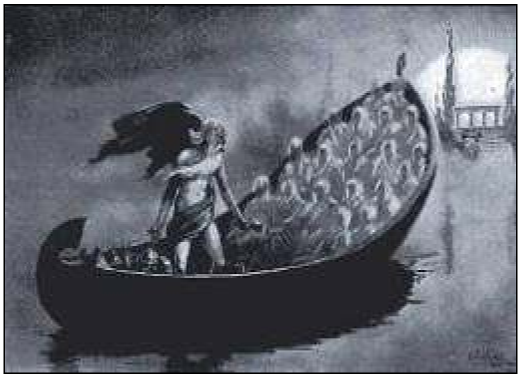
> *The steamer "ACCIDENTAL PRESIDENT" will leave immediately for the above-named resort [Salty Styx]. Take cars 9th and Arch. Passengers are requested to take sufficient clothing, as the stay may be prolonged. On account of the Great Rush to the Saline Shores, during the last six years, a new Hotel has been erected, called the "Usurpation" House, capable of accommodating the whole democratic party -- no distinction among the quests. Conservatives, Copperheads, Traitors, Blackguards, &c, will be treated alike. A prominent man will be on hand to grant pardons. On the trip Grandmother Buchanan will related the story "How he aided and abetted the Rebs!" A prominent Reader will recite the "Story of Arnold." A band of Renegade Republicans: will perform Andy's favorite, "We'll all drink Stone Blind." Liquors, (White House Vintage,) free. PROPOSALS RECEIVED for BURYING the DEAD DOG. -- P. Brownlow, Undertaker.*

"Across the River Styx," Cleveland Plain Dealer, February 9, 1902, deals with a local issue, the displacement of Cleveland Public Schools Director Bell from the Republican primary by his "Former Political Friends."

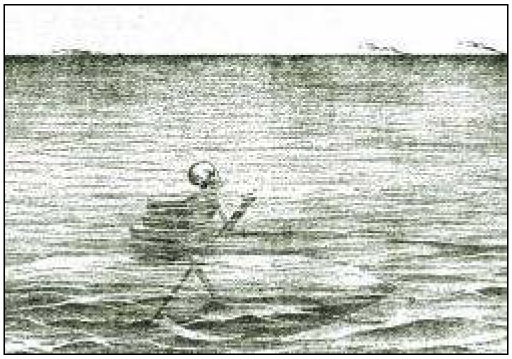




Charon: "Just as well keep up with the times and satisfy my Patrons." -- Harpers, November 1907

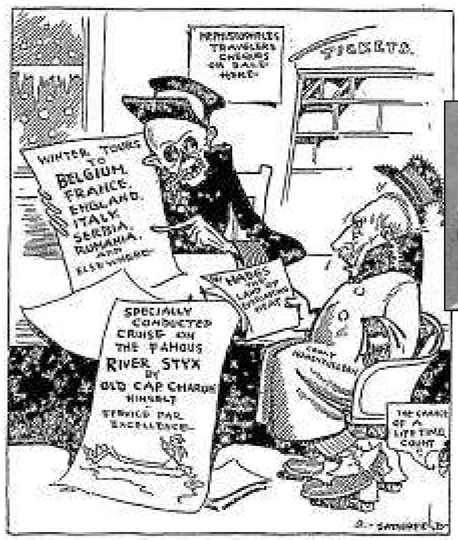


Charon (who has just installed a gasoline engine): "If there are any of you shades who know hot to run this engine, you'll get your trip free!" -- Harpers, August 1912



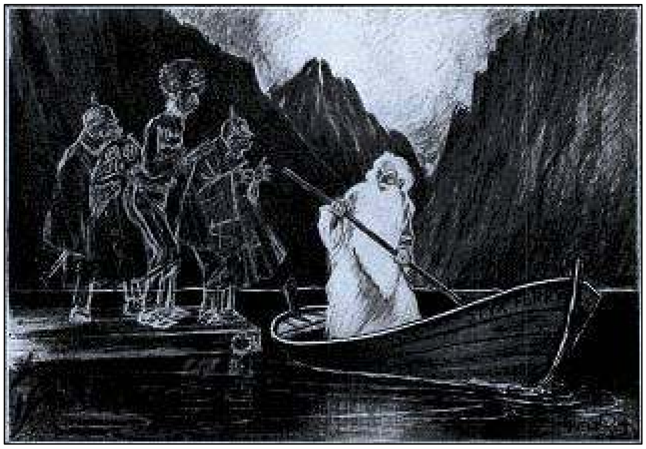
Charon steers a submarine in this 1914 Literary Digest cartoon, "The New Death."

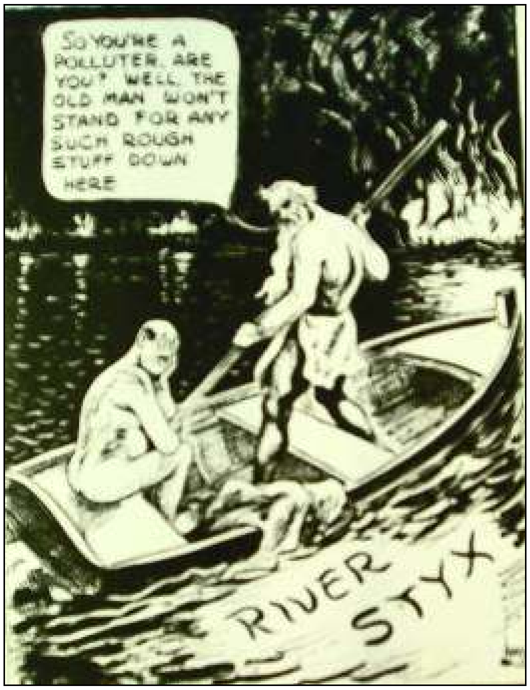
To the right, another Great War commentary. Count Hohenzollern became King Ferdinand of Romania in 1914 and in 1916 presided over his nation's entry into the war.



TRAVELERS CHEQUES ON SALE HERE
TICKETS.
WINTER TOURS TO BELGIUM, FRANCE, ENGLAND, ITALY, SERBIA, RUMANIA, AND ELSEWHERE
HADES THE LAND OF EVERLASTING HEAT
SPECIALLY CONDUCTED CRUISE ON THE FAMOUS RIVER STYX BY OLD CAP CHARON HIMSELF SERVICE PAR EXCELLENCE
COUNT HOHENZOLLERN
THE CHANCE OF A LIFETIME, COUNT

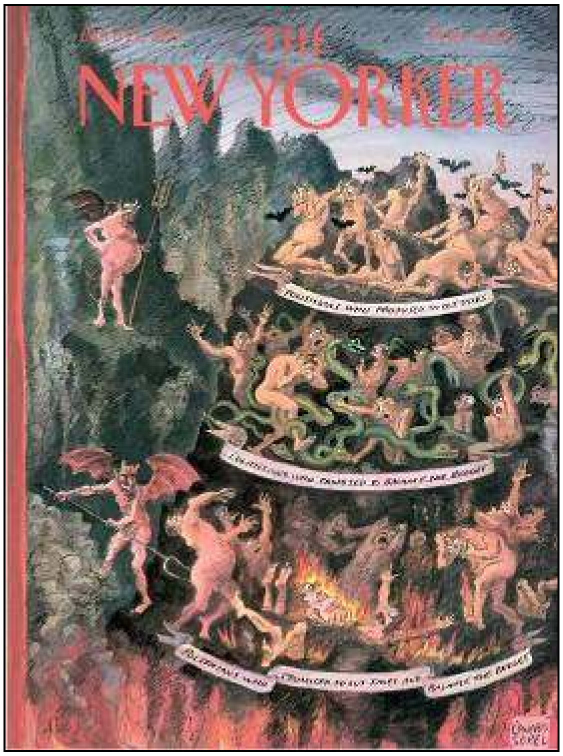
Charon: "I'll take you across, gentlemen, but the Styx is infested with U-Boats, and you travel at your own risk." -- Harpers, November 1918




SO YOU'RE A POLLUTER, ARE YOU? WELL, THE OLD MAN WON'T STAND FOR ANY SUCH ROUGH STUFF DOWN HERE
RIVER STYX

From the Izaak Walton League Monthly, 1922 or 1923,

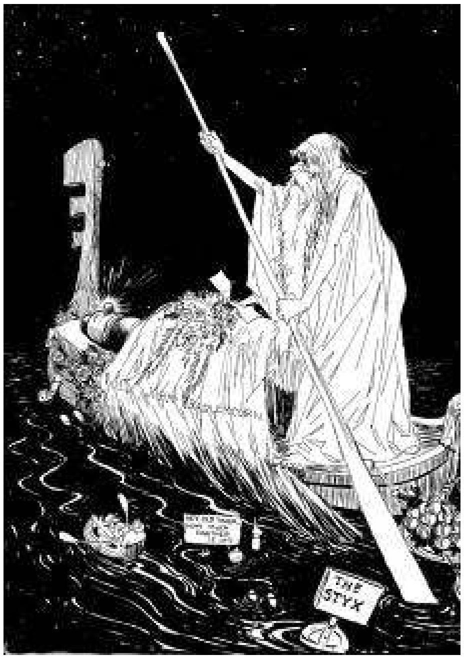
So you're a polluter, are you? Well, the Old Man won't stand for and such rough stuff down here.


THE NEW YORKER

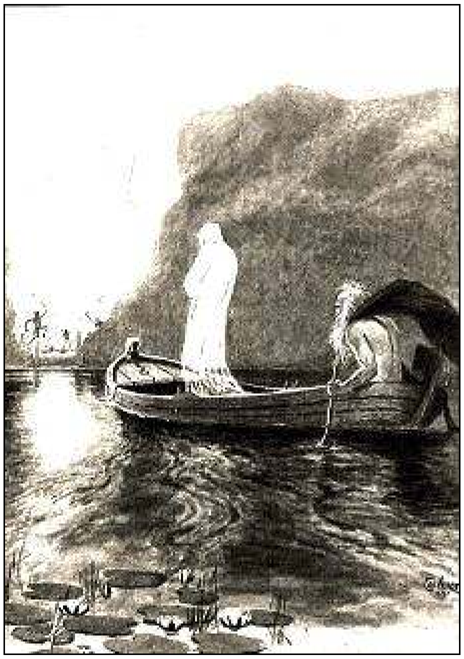
And at the risk of equating an oar to a pitchfork, the Dantesque cover of the April 21, 1997, New Yorker cannot be omitted.

Politicians Who Promised to Cut Taxes
Politicians Who Promised to Balance the Budget
Politicians Who Promised to Cut Taxes and Balance the Budget

Prohibition, of course, was a frequently-cartooned target.



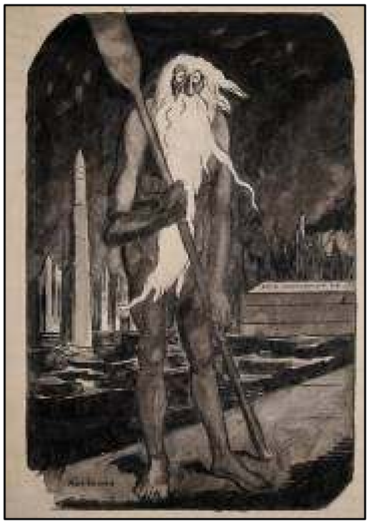
Jay N. Darling, "Over the River," Des Moines Register, January 16, 1920. Old John Barleycorn on the River Styx, "Hey old timer, how much farther is it?" a reflection on prohibition



"From One Dry State to Another," Harpers, February 1920

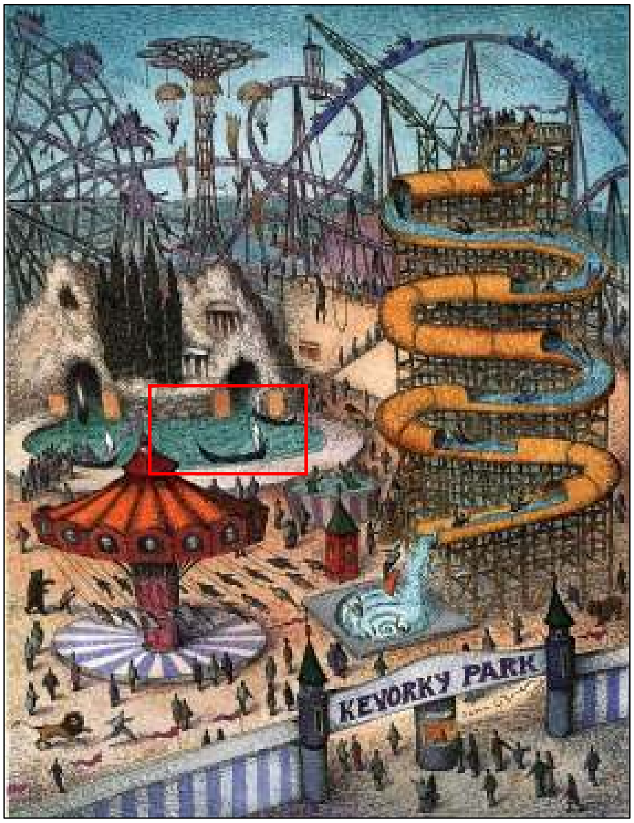
Art Young, "Charon, The Ancient Ferryman of the Styx, Now Retired, Inferno: A Journey Through Hell Six Hundred Years After Dante (1934).

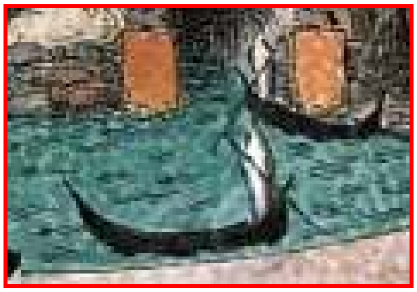
Hell, like modern society, is rapidly industrializing and Charon has been forced into retirement by a younger captain. Charon is now a mere loiterer on the river's docks. The industrialized "Styx Navigation Co." in the background calls for a newer, commercially-friendly face. Young was best known for his contributions to the Socialist monthly.

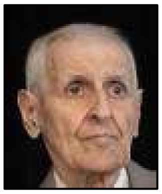


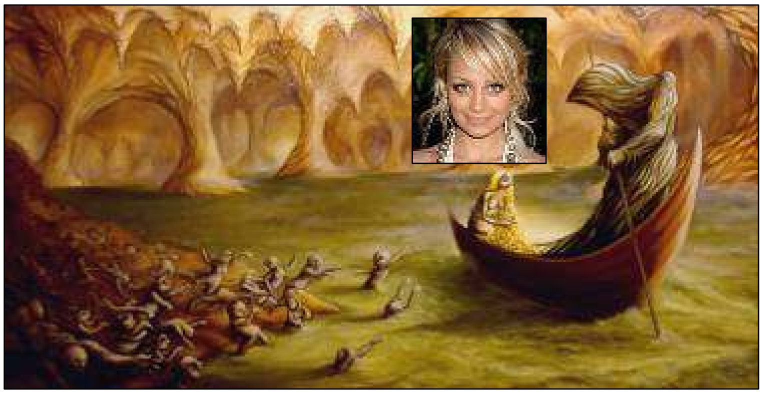
New Yorker cover, February 21, 1994

Kevorky Park, an amusement park with rides on which people can commit suicide, refers to Dr.Jack Kavorkian, an exponent of euthanasia.









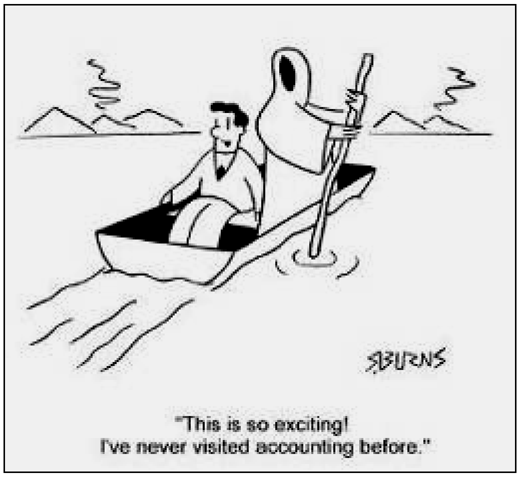
Bradley Platz, "Charon and the Shades" (2007). On the boat with Charon, Nicole Ritchie -- modern celebrity and wealth -- is dry and emaciated, without physical beauty. Gold is pours from her mouth. Souls trapped in purgatory swarm the craft, but without money for Charon, remain eternally stranded.

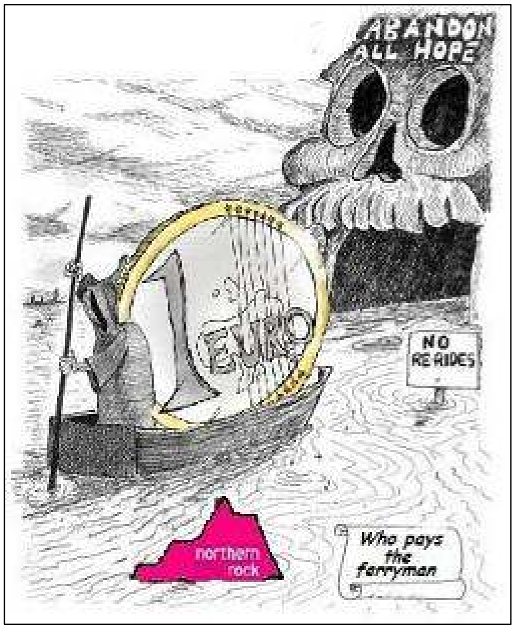
In the words of the artist,

> *The painting represents celebrity privilege as the continuation of the aristocratic privileges that have extended back to the time of myths and gods.*

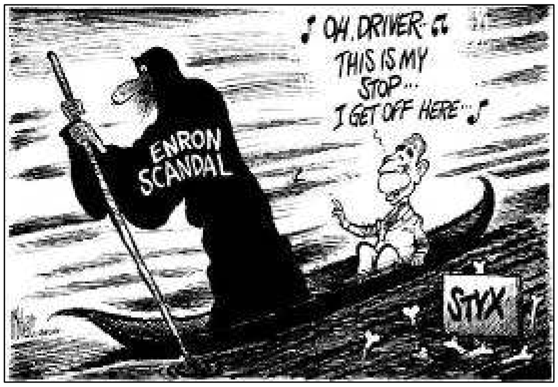
How have we progressed regarding gender equality? Consider the cartoon subjects pictured in this chapter. Not until 1885 do we have a female, only three out of 15 subjects, to be sure, but at least included. Our next female, not until 2007, is noted for being noted

Charon today is increasingly garbed to resemble the Grim Reaper.

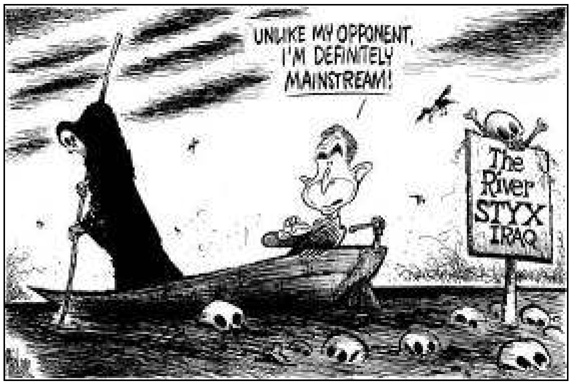

SBURNS
"This is so exciting!
I've never visited accounting before."


ABANDON ALL HOPE
EURO
NO REFUNDS
northern rock
Who pays the ferryman

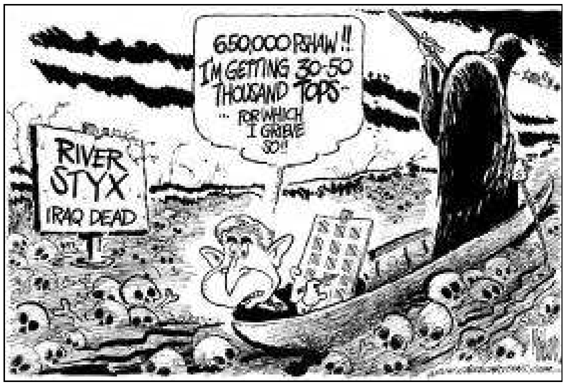
Three George W. Bush cartoons by Mike Lane


♪ OH, DRIVER ♫ THIS IS MY STOP... I GET OFF HERE ♪
ENRON SCANDAL
STYX

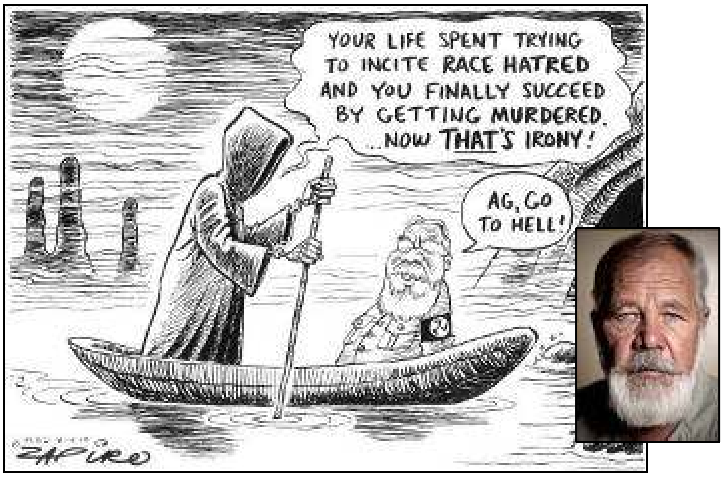
"Enron Boat," February 6, 2002


UNLIKE MY OPPONENT, I'M DEFINITELY MAINSTREAM!
The River STYX IRAQ

"The Mainstream in Iraq," October 18, 2004


650,000 PSHAW!! I'M GETTING 30-50 THOUSAND TOPS - ... FOR WHICH I GRIEVE SO!!
RIVER STYX IRAQ DEAD

"River Styx Iraq," October 12, 2006


YOUR LIFE SPENT TRYING TO INCITE RACE HATRED AND YOU FINALLY SUCCEED BY GETTING MURDERED. ...NOW THAT'S IRONY!
AG, GO TO HELL!
ZAPIRO

Eugene Terre'Blanche going to Hades, Mail & Guardian, April 8, 2010. Terre'Blanche was a member of South Africa's Herstigte Nasionale Party during the apartheid era and later was known for threatening civil war to maintain white rule in South Africa. Terre'Blanche was imprisoned for assaulting a black petrol station worker and the attempted murder of a black security guard in 1996. In 2010, he was beaten to death by two laborers over a wage dispute.

Through the interpretations of myth, the schools of art, the social change that feeds it all, Charon glides onward, his portraiture altering from prime to aged, from kind to fierce, from angelic to monstrous, but the relevance of his labor is undiminished.

CHAPTER 35

UNDERGROUND RIVERS IN THE FINE ARTS

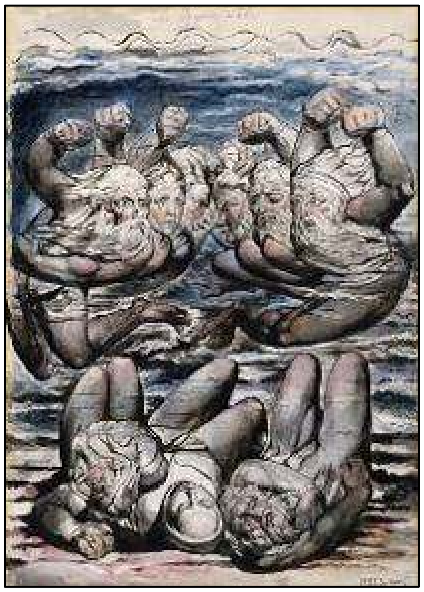
If in fact the image of the underground river permeates Western culture, we would expect to encounter such representations in the fine arts. And indeed, this is the case. This chapter cites a few examples in painting, photography, performance and architecture. We've seen examples in prior chapters and we will see others in the journey ahead. Although music could be folded into this chapter, we'll give it its own sage in the chapter to follow.

The Underground River in Painting and Etching

The previous chapter makes this section a short one. Because most underground river artwork is historically of the River Styx -- our ferryman Charon usually claiming the center -- we're left with a much-reduced catalog.

Before we look at underground rivers, sans Charon, in painting, however, we remind ourselves that from a broader perspective, we're looking at circularity, the metaphor of the Renaissance (Chapter 7). As expressed by Vincent Van Gogh in an 1888 letter to Emile Bernard,

> *We're still in the position of believing that life is flat and goes from birth to death. But life too is probably round, and far superior in extent and potentialities to the single hemisphere that's known to us at present. Future generations -- probably -- will enlighten us on this subject that's so interesting -- and then science itself -- could -- with all due respect -- reach conclusions more or less parallel to Christ's words concerning the other half of existence.*



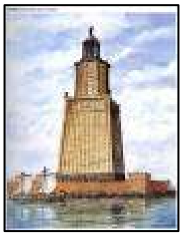
To the right and below are three William Blake Inferno etchings (1824-1827) not included in the previous chapter because they don't portray Charon. They are explicit, however, in Stygian location.

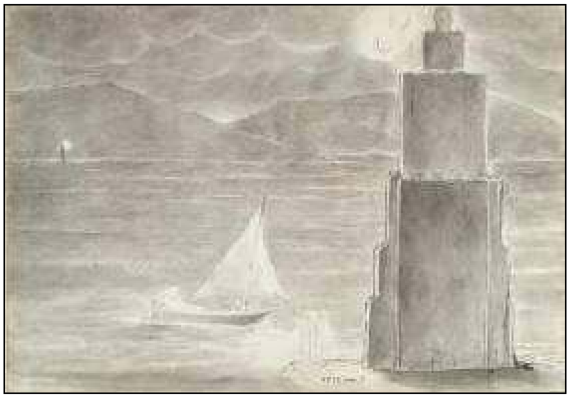
Unlike "The Stygian Lake with the Ireful Sinners Fighting" to the right, Blake's engraving below and on the left seems decidedly un-infernal in several aspects:

The summer-day setting,

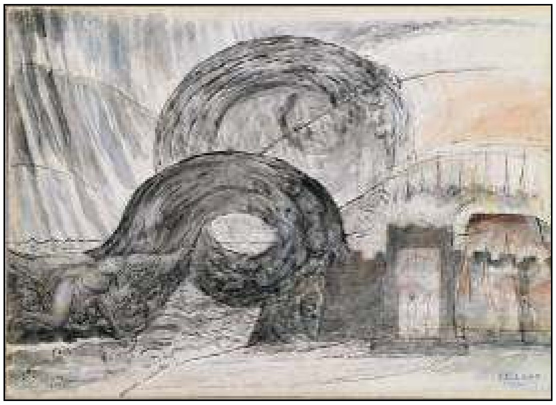
The recreational sloop,

The edifice resembling the Lighthouse of Alexandria, a Wonder of the Ancient World.





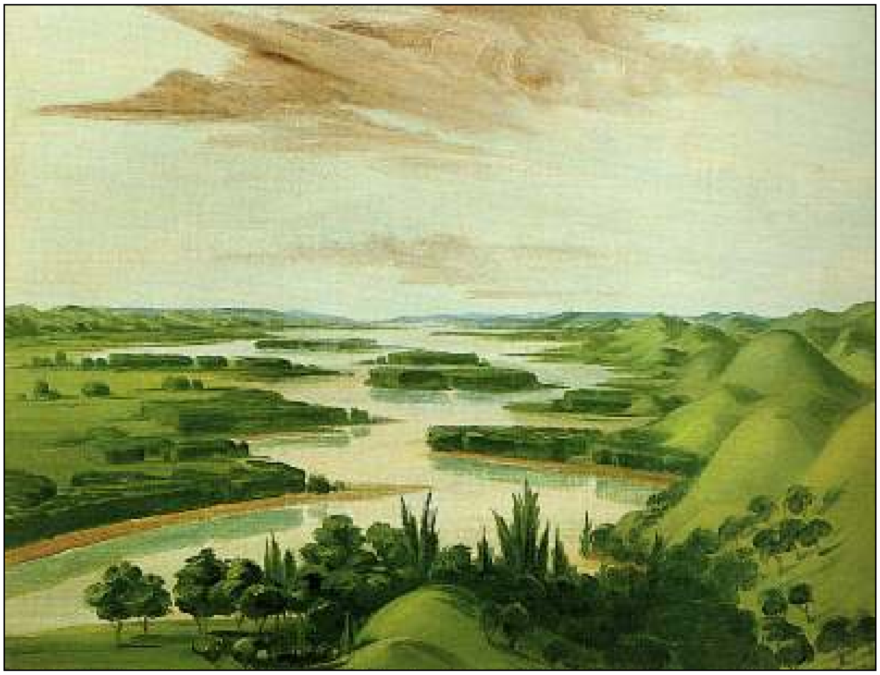
"Dante and Virgil about to Pass the Stygian Lake"



"The Angel Crossing the Styx"

Perhaps the most we can conclude from Blake's underground-river etchings is that artistry is granted broad license.

George Catlin (1796-1872), an artist with a bent toward geology, is best known for his illustrations of Native Americans and landscapes, an example of which, "Lower Missouri River," is shown below.



Catlin's interests were not exclusively what could be seen, however. Underground lakes and rivers were central to his geologic treatise, The Lifted and Subsided Rocks of America (1870). The elevation of mountain chains, he explained, left vacant cavities underneath, "and the ever-ready ingredient to fill those spaces is water." Citing Mammoth Caves and Native American legends, Catlin argued the magnitude of these reservoirs was necessarily enormous. In reference to the Noachian flood, "If suddenly raised and let loose upon the surface, [the water] would deluge the globe."

These reservoirs, not subject to evaporation, are fed from the surface, it being the nature of mountains to receive more precipitation than do the surrounding plains. Resultant overflow at the top of these "subterraneous cavities" thus produces an underground river flowing towards the sea in the direction of the inclination of the chain. The Gulf Stream consists of two vast subterranean rivers, one carrying the drainage of the Rockies, the other that of the Andes. "Submontagne aqueducts, with currents, are the necessary consequence, is proved by a law of nature." It's unfortunate that Catlin made no painting of what lies beneath the painting above.

From the Geological Magazine 7, 1870, review Catlin's work.

> *Catlin, the hero of our boyhood, the historian of the North American Indians, comes before us here in a new character, as a writer on physical geology, geography, and ethnography; and although we confess to a feeling of fond regret in not meeting with a single buffalo-hunt, or a Pawnee chief in his war-paint in the book before us, it is a wonderful book nevertheless. No, Mr. Catlin has taken up the pen once more, not, however, to write on Indiana, but on the great physical features of Northern and Central America, and to offer us his own opinions on the origin of mountains and valleys, rivers and seas, and the vast changes that have taken place in the relation of land and water since man, as civilized man, occupied Central America. Mr. Catlin, if not a profound scholar is, at least, a great traveler, and his observations therefore deserve our attention, even if we are unwilling to accept his theories.*
>
> *Along the shores of the United States enormous volumes of fresh water are constantly poured into the sea from subterranean rivers. The coasts between Nice and Genoa, those of Algeria, Istria, Dalmatia, and even the shores of the Dead Sea (destitute of substantial streams) have all their submarine rivers jetting up into the sea. Nor will anyone, familiar with the phenomena of mountains and rivers, be disposed to object to the assertion of Mr. Catlin of the vast quantity of subterranean channels in the Rocky Mountains into which a very large proportion of the rainfall finds its way, probably not to reappear until it is poured into the sea itself by some submarine vent. But it may be very reasonably doubted whether there is any more connection between these fresh-water rivers, with submarine outlets, and the Gulf Stream, than between it and the waters of the Amazons or the Mississippi itself.*

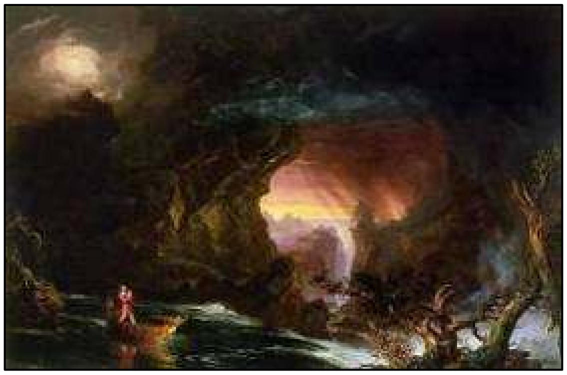
Geological Magazine adds two notes that bolster Catlin's reference to an underground river from the Rocky Mountains to the Gulf of Mexico:

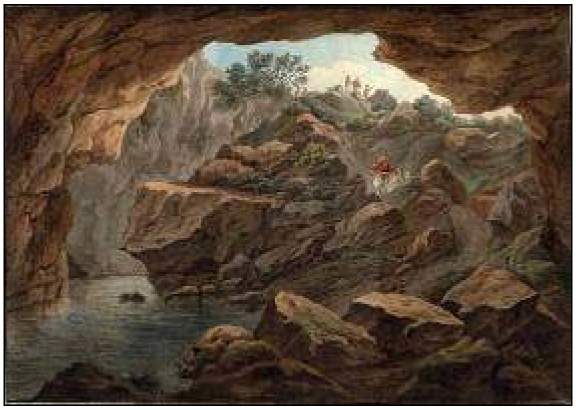
1. Abbe Brasseur de Bourbourg's 1861 translation of Mayan codices citing (in the review's paraphrase) "a subterranean river under the Rocky Mountains." It seems, however, that the reviewer read more than what was translated, as while the legend wasn't sited under the Rocky Mountains.
2. The report of Mr. L. Harper, "Professor of Geology, U.S.A.," that "a subterranean outlet of the Great Salt Lake has been discovered at Corinne, in the territory of Utah, U.S., which... may largely contribute to the Gulf Stream." We'll deal with Great Salt Lake outlet lore in Chapter 86, The Rio San Buenaventura, but we'll include this citation here, as it relates to Catlin.

Though doubtful of Catlin's expertise, Geological Magazine endorsed his Rockies-to-Gulf subterranean thesis.

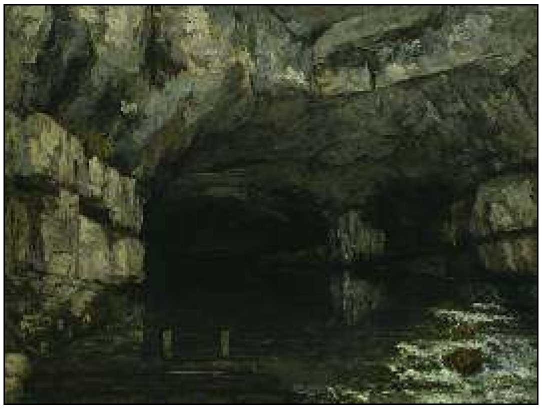
"The Voyage of Life, Manhood" (1842) by Thomas Cole is set in a Stygian river. Of two lightings, one illuminates hope for the hero successfully riding the rapids. The second is created by the halo of his guardian angel.

While the voyager's stance seems Charonesque, allegorical allusion to the old ferryman seems a bit far-fetched.



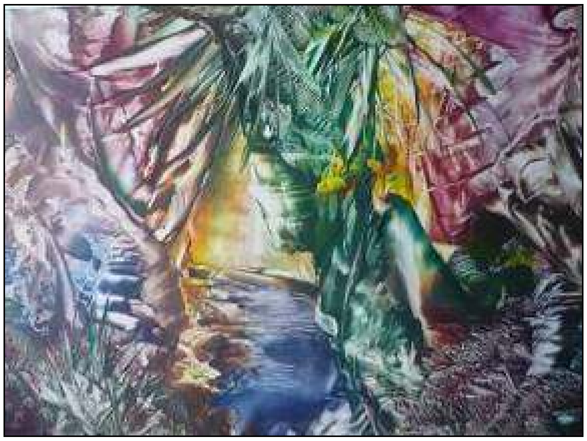


"A Katabathra of Lake Copias" (1816) by Edward Dodwell

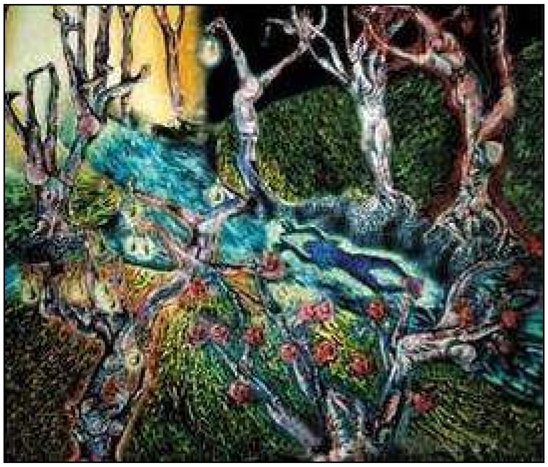


"La Source de la Loue" (1864), Gustave Courbet

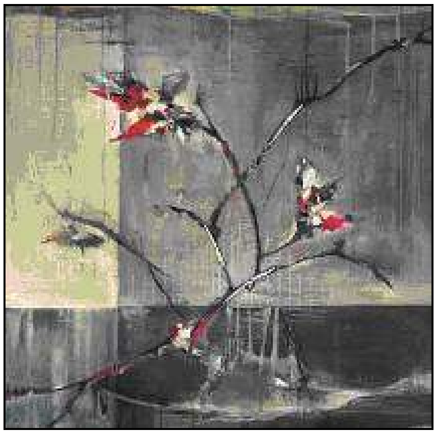
A few paintings more contemporary.



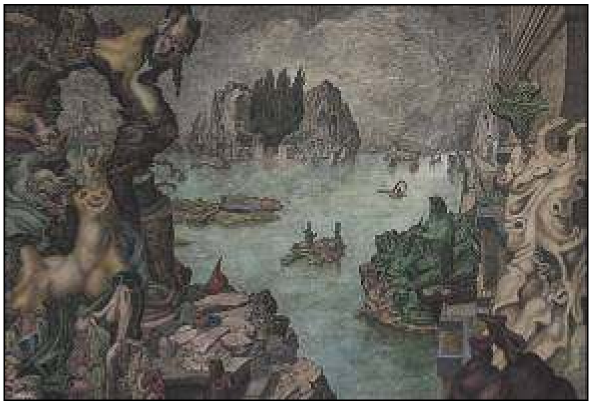
Anne Kent/Ann Neale's encaustic "The Underground River in the Forest," we are pleased to observe, aren't as ominous.



Julie Ward's "The Underground River" speaks of a journey through darkness. Are the apples and pears (goddess symbols) magical fruits that sustain and bring joy to our labors or are they poisonous temptations that sway us off the track?



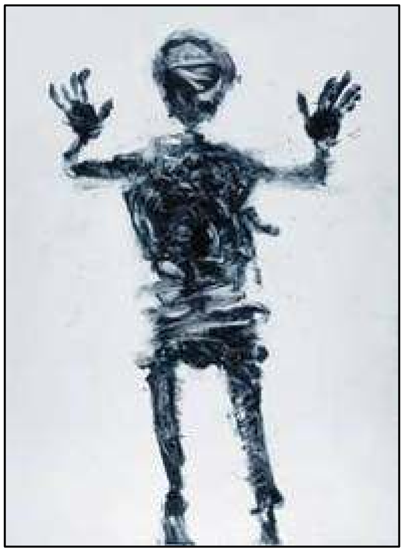
"Underground Stream" by Terri Burris. Whether the red is foliage, bird wings or something oriental may be up to the viewer.



"Styx" (2001) by Erik Heyninck "Böcklin's Island of the Dead in the distance is an indication that it is not the end, but that there's a river that leads us further."

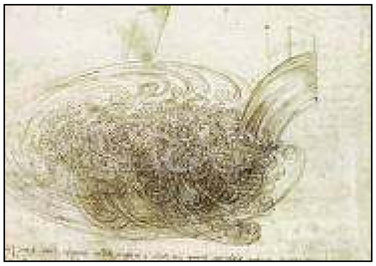
Quoting from the Center for Maine Contemporary Art catalog for Alan Magee's 2007 exhibition -- and resolutely retaining from further comment,

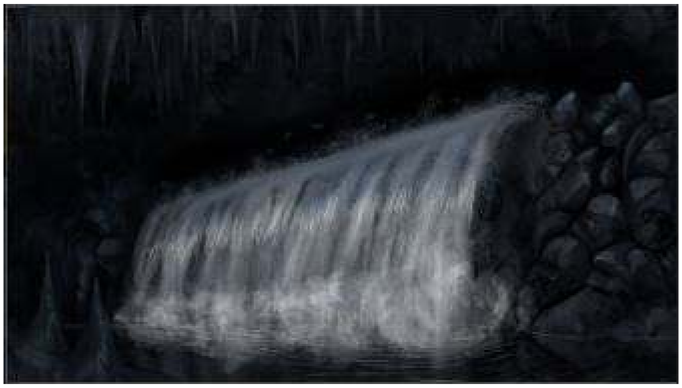
> [From the Underground River] *addresses the fragility of our humanity, namely our capacity for violence -- violence directed towards others as well as ourselves. In these works Magee examines the human condition in today's culture of greed, commerce, and superficiality. His is a profoundly concerned art that is full of compassion and fellowship. In his study of human frailty, it is ultimately indifference that Magee decries.*
>
> *From the Underground River presents this body of work in depth for the first time, and offers a rare opportunity to experience a wide spectrum of Magee's most personal and provocative images.*



The Underground River in Digital Art

Ryan Corrigan's "Waterfall Cavern" brings to mind da Vinci's sketch.





The Underground River in Photography

Consider "Underground River" by John Welch, 2000. Not all is as it appears, however, as described by the photographer,

> *Basically, I generated two terrains, edited one for the floor and one for the ceiling, flipped the ceiling over and placed it on top of the floor. Then I added a water plane for the river and used a limestone texture for the rock.*

Chapter 39, Karstology, contains additional photographs of underground streams.

The Underground River in Dance

"Underground River" is Jane Comfort and Company’s Bessie Award-winning meditation on the dichotomy of an artist’s inner creative world and the external reality. The work explores the rich, inner life of a girl who appears to the outer world to be comatose. It's good that we're told this.

The performance begins with four dancers walking onto stage. A skeletal umbrella with ribbons descends from above. The dancers remove ribbons and make a ribbon dancer puppet that all four manipulate.

Tim Dalman's 1999 internet posting, "John Sherwood's Dance, A Map for Understanding Unconscious Transactions between Groups and Newly Appointed Leaders" employs an above-ground vs. underground river as a dance metaphor for social interaction.

> *It is possible to view that which occurs in groups and among people as occurring in either of two layers. One layer is aboveground, but flowing beneath the surface is an underground stream.*
>
> *If all to which a person pays attention in group functioning is manifest behavior (what people say and do, or fail to say and do), then we could say they are fishing in the aboveground level. But if one is also keen to examine and react to the corporate unconscious or the psychodynamics in group functioning, then we might say that they are fishing in the underground stream.*

This all makes sense, we suppose.

The Underground River in Drama

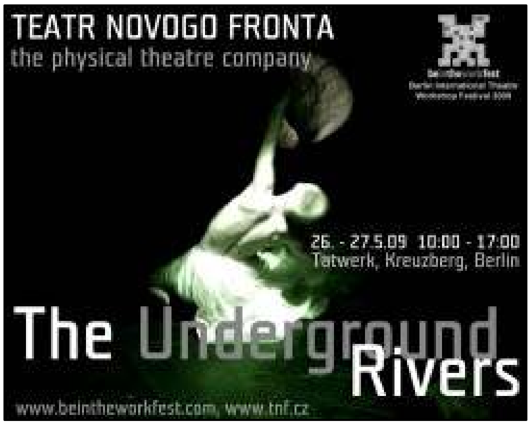
Regarding the sewer as dramatic setting, Charles Dickens' "Underground London," (the weekly magazine we encountered in Chapter 47), July 20, 1861, offers the following.

> *There are more ways than one of looking at sewers, especially at old London sewers. There is a highly romantic point of view from which they are regarded as accessible, pleasant, and convivial hiding-places for criminals flying from justice, but black and dangerous labyrinths for the innocent stranger. Even now, in these days of new police and information for the people, it would not be difficult to find many thousands who look upon them as secret caverns full of metropolitan banditti. When the shades of evening fall upon the City, mysterious whispered "Open sesames" are heard in imagination near the trap-door side-entrances, and many London Hassaracs or Abdallahs, in laced-boots and velveteen jackets, seem to sink through the pavement into the arms of their faithful comrades. Romances, as full of startling incident as an egg is full of meat, have been built upon this underground foundation, and dramas belonging to the class which are now known as "sensation" pieces, have been placed upon the stage to feed this appetite for the wonderful in connection with sewers.*
>
> *I have some recollection of a drama of this kind that I saw some years ago at one of the East-end theatres, in which nearly all of the action took place under huge dark arches, and in which virtue was represented in a good strong serviceable shape by a heroic sewer-cleanser. Much was made of floods and flooding, which the flusher, who played the villain of the piece, seemed to have completely under his control; and it was not considered at all singular by the audience, that a dozen men and women should be found walking high and dry under these mysterious arcades, as if in some place of public resort.*

May Sarton published The Underground River, a Play in Three Acts in 1947, concerning the French resistance, but it wasn't performed until 1955.

Teatr Novogo Fronta was established in St. Petersburg in 1993. Their early work resulted from experiments in the relationship between the actor's body and the event space.

To the right is a poster from the 2009 Berlin International Theater Workshop. Why this work is called "Underground Rivers" perhaps eludes us because we don't speak Russian.


TEATR NOVOGO FRONTA
the physical theatre company
26. - 27.5.09 10:00 - 17:00
Tatwerk, Kreuzberg, Berlin
The Underground Rivers
www.beintheworkfest.com, www.tnf.cz

Or for something a bit more melodramatic, we have Within the Gates (1900) by Elizabeth Stuart Phelps, a portion from Scene IV which follows.

> *After a moment's interval, following The Angel quickly. Enter Dr. Thorke (his robe is much paler, but still of a purplish tint. It is now clasped by the golden cross.*
>
> *He cries aloud: Azrael!*
>
> *Echo from the caverns: Azrael!*
>
> *Azrael makes no reply. Moves on steadily.*
>
> *Dr. Thorne in a lower voice: Azrael, Angel of Death!*
>
> *Azrael turns his head, but without pausing.*
>
> *Dr. Thorne: In the name of Him who strove with thee, and conquered thee -- whither goest thou, Azrael?*
>
> *Azrael pauses. He looks over his folded wing at the man; regards him steadily; does not speak; moves on again. Dr. Thorne utters an inarticulate exclamation. He follows the Angel. Halfway down the path he stops, perplexed. His expression is anxious. Azrael moves on. He does not again look back; glides to the edge of the ravine. The scene darkens. The Angel does not pause, but can be seen to cross the gulf fleetly: He does not fly, but appears to tread the air across the space. Vanish Azrael.*
>
> *Dr. Thorne stands alone in the gloom. His eyes are fixed upon the spot where the Angel disappeared. A low, rushing sound, as of water, can now be heard.*
>
> *Dr. Thorne shudders; speaks: It seems like an underground river. Horrible!*
>
> *He calls: Azrael! Tell me thine errand -- in this fearful place!*
>
> *Azrael neither replies nor appears. It grows very dark. The perspective of the Heavenly City fades. The rushing of the river can be heard.*

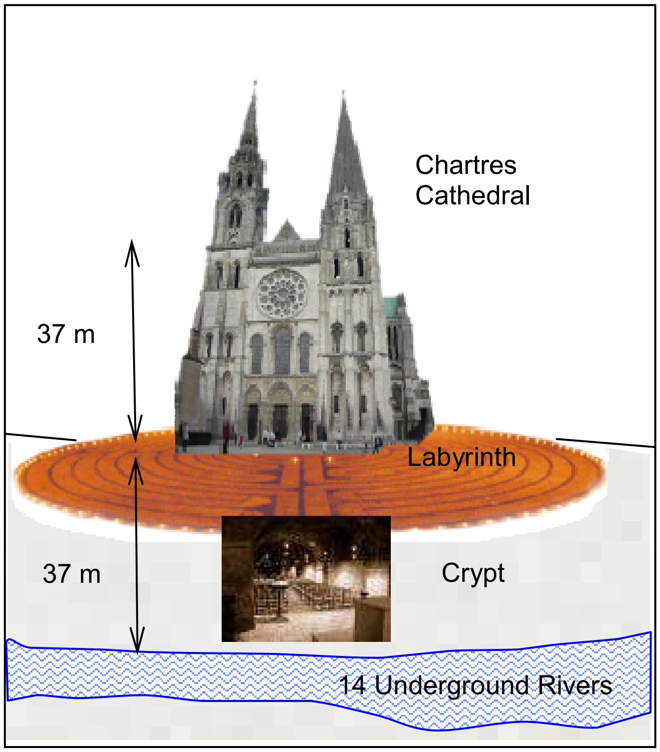
The Underground River in Architecture

In the 1970s, Terry Fox produced sculptures, drawings, environments and performances based on the theme of the labyrinth of Chartres Cathedral. According to the artist,

> *Although it* [the labyrinth] *exists physically on the floor of the cathedral, it is not really an object at all; it is a metaphor.*

New age lore claims that 14 underground streams converge beneath the labyrinth, charging the cathedral with energy. In actuality, as demonstrated by the Opera Garnier, a single backfilled watercourse is sufficient to charge the basement with water.

Fox believed that the architects set the height of the nave equal to the river's depth below ground.


Chartres Cathedral
37 m
Labyrinth
37 m
Crypt
14 Underground Rivers

It's been a varied journey, traversing the underground waters of the fine arts. Like the writers' metaphors, the artists' allusions and manifestations reflect the breadth of creativity.

As we move forward to modern science, however, let us not forget that in terms of human expression, underground rivers flow as much through the right half of our brain as the left.

CHAPTER 36

UNDERGROUND RIVERS IN SOUND AND SONG

The sounds of an underground river cannot be segregated from the river itself. In this chapter we wish to make ourselves watchful for how frequently the audio aspect engages the minds of observers. We want to be listening for the listening, so to speak.

We'll begin with the passive. Musical minds have undertaken to create, or at least capitalize upon, the sounds of water beneath our feet. Then we'll migrate to the active, how underground streams have contributed to tunes we might find ourselves humming.

The Underground River in Sound

The sound of underground rivers has often been reported, as evidenced by journalism from the late 1800s.

Bluffton Chronicle, Aug. 1, 1894 Wabash County, Indiana	*Not far from the Huntington county line, in Wabash county, a farmer drilled a well to a depth of about sixty-five feet, when the drill ceased to strike anything solid, and by applying the ear close to the opening running water could be heard.*
Kendallville Standard Oct. 19, 1888 Whiteville, North Carolina	*What is claimed to be the roaring and rushing of water can be plainly heard and hundreds of people are visiting the spot. When in the vicinity of the supposed stream it can be plainly heard, but when a person lies flat upon the ground the phenomenon becomes really alarming. The sound indicates that the water is not any great distance down and that it is not a small stream, but a majestic river that is coursing unseen in the bowels of the earth on its way to the sea.*
New York Times March 11, 1897 Lost River, Indiana	*The water has now ceased to flow from the cave, but any one standing near the entrance can hear the rushing of the torrent apparently hundreds of feet below.*
The Daily Argus News Aug. 14, 1895 Jefferson County, Tennessee	*Away in the distance is heard the roaring or a much larger stream, which is thought to be a veritable underground river of no small dimensions.*
New York Times Nov. 14, 1888 York County, South Carolina	*All agree that it is the sound of running water over a shoal perhaps 100 feet lower down, and that it must be a large stream.*

How the sounds of subterranean streamflow provoke our imaginations is noted by no less than Nathaniel Hawthorne in "Night-Sketches," in Twice-Told Tales (1837).

> *It is strange what sensations of sublimity may spring from a very humble source. Such are suggested by this hollow roar of a subterranean cataract where the mighty stream of a kennel precipitates itself beneath an iron grate and is seen no more on earth. Listen a while to its voice of mystery, and Fancy will magnify it till you start and smile at the illusion.*

Hawthorne's "kennel" is a gutter along a street.

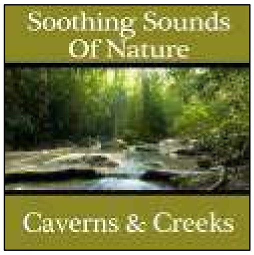
Moving to the present, we've condensed "Artist's Project Brings Sound of Underground Downtown Stream to Surface," Lexington Herald-Leader, July 27, 2011, as follows.

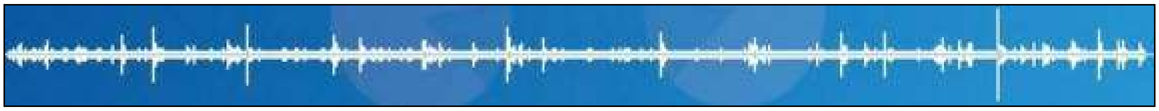
> *There has long been no visual or audible evidence of the rushing water that runs just below the high-rise buildings and busy streets of the Lexington*
>
> *Artist Bill Fontana will unveil his newest sound sculpture, Surface Reflections. The piece will bring the sounds from microphones hung over the Town Branch flowing just below the Lexington Financial Center.*

> *The sound of the water will be live, but manipulated into a cascading effect through eight speakers along the landscaped path where downtown workers can escape the sun and traffic clamor.*
>
> *Fontana has done projects with famous rivers from Cleveland's Cuyahoga to Europe's Danube, but there he was interpreting a well-known body.*

Hark.com's "Water Cave Underground Waterfall Ambience Nature Loop" and Dr. Sound Effects' "Underground River" in "Soothing Sounds of Nature - Caverns & Creeks" typify of what's now available on the sound clip market

The soothing sequence of minutely-interrupted white noise creates an underground water sound, perhaps, but could as well be from an open faucet in an otherwise quite kitchen.





At the risk of being considered less than romantic, we should probably conclude that water tends to sound like water, independent of its environment. If it's in a dark place, we're simply more likely to listen with enhanced appreciation.

The Underground River in Music

We must first listen, of course, but the human spirit strives to then create.

We've recalled the legend of Orpheus and Eurydice elsewhere in our journey, Chapter 33 being one encounter, but here we'll note an operatic rendition today in its fifth century of performance, Claudio Monteverdi's 1607 L'Orfeo.

L'Orfeo, Act 3:

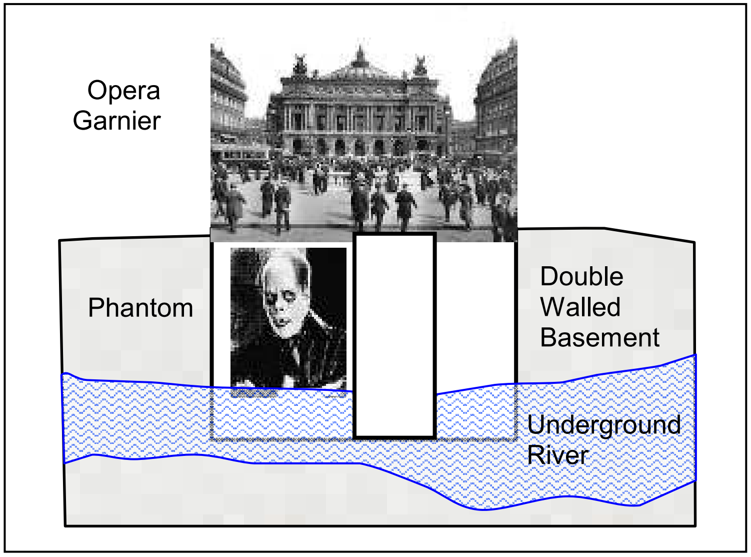
Orpheus (a tenor) attempts to pass into Hades to find Eurydice, but his way is barred by Charon (a bass, as we might expect), who declares that no living body may board his boat. Orpheus protests that he is no longer living, for, with his wife dead, he no longer has a heart. Cantankerous Charon is unmoved, but when Orpheus plays his lyre, the boatman is lulled to sleep and the hero crosses over the Styx in the boat.

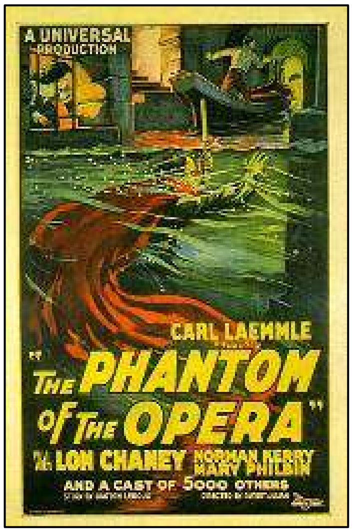
Should we flip ahead to Chapter 57, Cargo Conveyance, we'll see how Georges Bizet's Carmen relates to an underground river, but we'll not reveal the outcome, as it involves a secret passage.

Opera's most noted subterranean setting doesn't stem from an opera at all; it's from Gaston Leroux's novel, The Phantom of the Opera (1910). The tale's since been produced by Hollywood, a notable version being the 1925 silent film, and later on stage, Andrew Lloyd Webber's 1986 musical, the most successful. A novel set under an opera house becomes an opera itself, 76 years later.

Phantom is set in the gothic "Opera Populaire," an edifice inspired by the real Opera Garnier in Paris. The "subterranean lake" above which today's guidebooks say the Garnier sits is in fact the building's fifth and lowest cellar, flooded by a buried branch of the Seine, encased by a double wall of concrete and used for hydraulic manipulation of stage machinery. The operatic Phantom's chamber would seemingly lie between the two walls.

The 1925 poster indicates the seepage challenge.





Dramatic highlights of the 1925 film include.

The journey into the cellars, a procession of arched levels and underground lakes through which the Phantom rows a gondola while Mary's lace train trails into the water.

The Phantom entering the underground lake, disappearing until only the tip of his breathing tube shows as he exits to drown de Chagny's brother.

We needn't rely on the Hollywood and London entertainment industry, however, to relate opera to underground waters. Here's an excerpt of "The New Opera House in Paris" from the nuts-and-bolts Manufacturer and Builder, July 1875.

> *The excavations were commenced in 1861, and carried 20 feet below the street in the main parts of the building and 50 feet under the stage, which occupies a surface of over 25,000 square feet. Very soon the water was encountered which descends from the bights of Belleville, forming a large subterranean river, passing through all the permeable layers of earth, and running into the River Seine. In order to make a foundation under such circumstances the whole site was surrounded with a double row of piles 20 feet long, driven down 80 that only 1-1/2 feet was left projecting above the surface of the water, while between the piles hydraulic concrete was poured, so as to make a water-tight wall, inside of which the water was pumped out and the foundations laid. This work absorbed half a million dollars, and was only accomplished under great difficulties, eight large pumps working night and day being required to enable the workmen to place the concrete in a sufficiently dry soil, while at the same time measures had constantly to be taken to remedy the continual caving in of the surrounding soil.*

Underground rivers themselves are long-established venues for musical performance. We'll cite Pictorial Guide to the Mammoth Cave, Kentucky (1851) by Horace Martin several times in subsequent chapters, but here's a pertinent except related to Echo River.

> *We remember well on the occasion of a late visit to the Cave, that the whole boat's company joined simultaneously in song while gliding down this River Lethe. How sublime, how truly religious was the effect.*
>
> *Sometimes a full band of music has been tried on the Echo. What the effect has been can be imagined. Truly may it be said that such things cannot be obliterated from the memory. Let us add that they ought not to be, for they assuredly make better creatures of us all.*

Jenny Lind (1820-1887), "The Swedish Nightingale," forerunner of the modern pop icon, was mobbed by crowds of 30 to 40,000 upon her arrival in America and tickets to her show went for as much as $250. She visited Mammoth Cave in 1851, near the end of her concert tour managed by P.T. Barnum.

Lind is reputed to have sung while seated on the formation now known as "Jenny Lind's armchair." The 1910 doubly-misspelled postcard, "Jennine Linn Rested in this Armchair," is to the right.

As for Miss Lind's underground boat trip, that's included in Chapter 50.

Arm Chair, Mammoth Cave, Kentucky.
Jennine Linn rested in this Chair.

Also in Chapter 52, we'll offer a ticket to visit the underground waters of Luray Cavern in Virginia, but this is the chapter to promote the Cavern's organ concert.

In his The Hidden Messages in Water (2001), Masaru Emoto notes,

> *However, within natural water, no matter where it came from-natural springs, underground rivers, glaciers, and the upper reaches of rivers-complete crystals formed... My efforts to photograph ice crystals and conduct research began to move ahead. Then one day the researcher -- who was as caught up in the project as I -- said something completely out of left field, "Let's see what happens when we expose the water to music."*

The musical tastes of underground rivers remains unknown, however. What is certain is that performers sing of such rivers.

English composer Stephen Blumberg's "Subterranean River" was commissioned by the California Youth Symphony and first performed in November, 2011.

California Youth
Symphony
$10-00 - $15.00

In the words of the composer,

> *Early in the process of composing this music I heard in it evocations of moving water, sometimes tranquil, sometimes rushing, even torrential. There was also a sense of underground spaces -- dank, dark, cavernous, resonant, and echoing. In one passage the music slows to almost complete stillness and it suggested to my imagination a timeless, voluminous space, cathedral-like, with crystals and hanging stalactites above nearly motionless, pooling water. The various sections of the piece have tempo and character indications -- tranquil, calm; murky, menacing; turbulent, rushing -- that suggest different types of motion associated with the changing speed and flow of an underground river. I determined the title, Subterranean River, and as the piece progressed the music flowed through a changing succession of scenes and spaces, experienced through an imagined voyage.*

Drach Caves in Spain offers a rowboat concert every hour, a 10-minute classical performance by two violins, cello and harmonium on Lake Martel. The concert consists of four pieces:

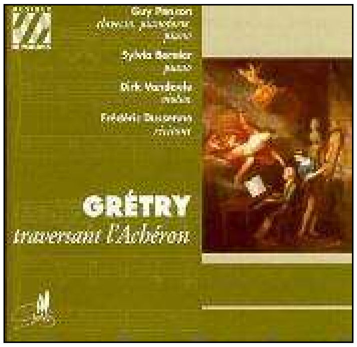
Caballero's "Galician Alborada"
Martini's "Plaisir D'amour"
Chopin's "Tristesse" (Study #3, Opus 10)
Offenbach's "Barcarolle," from "Tales of Hoffmann"

The concert's been offered since 1935

Cueva del
Drach
€11.50

Ten minutes isn't sufficient for a classical concert, course, but none of the composers have objected. We'll have more to say about the underground lake's name in Chapter 49, Subterranean Watercraft.

A few recordings for the aficionado,


GRÉTRY
traversant l'Achéron

André Grétry, Belgian, "Gretry Crosses the Acheron"

François-Bernard MÂCHE
Styx
pour deux pianos
DURAND S.A. Editions Musicales

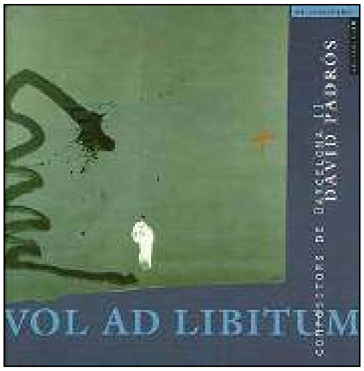
François-Bernard Mâche, French, "Styx" for 2 pianos, 8 hands

KANCHELI Styx GUBAIDULINA Viola Concerto

Giya Kancheli, Georgian, "Styx" for viola, mixed choir and orchestra

SWR MUSIC
hänssler CLASSIC
WOLFGANG RIHM
Musik für Oboe und Orchester | Styx und Lethe
Dritte Musik | Erster Doppelgesang

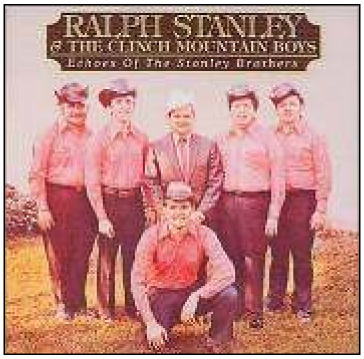
Wolfgang Rihm, German, "Styx und Lethe" for cello and orchestra


VOL AD LIBITUM
COMPOSITORS DE BARCELONA 11
DAVID PADRÓS

David Padrós, Catalan, "Styx" for piano and chamber ensemble
Album: Vol Ad Libitum

ΣΥΓΧΡΟΝΗ ΕΛΛΗΝΙΚΗ ΜΟΥΣΙΚΗ ΓΙΑ ΦΛΑΟΥΤΟ ΚΑΙ ΠΙΑΝΟ
CONTEMPORARY GREEK MUSIC FOR FLUTE AND PIANO

Panayiotis Demopoulos, Greek, "Styx" for flute
Album: Contemporary Greek Music for Flute and Piano



For those to whom "classic" means classic bluegrass, we met the Stanley Brothers, pioneers of that musical genre, in Chapter 32, To Cross the Styx. Echoes of the Stanley Brothers, remakes of 1971 and 1973 tracks, includes "River Underground."

On the far right: Ralph Stanley and the Clinch Mountain Boys performing in Cumberland Caverns, Tennessee, 2011. Stanley: "I hope we can get out."

"River Underground,"

When I was a young lad
I wandered one day
An unknown cavern
Went there to play.

Heard Water running
with an echoing sound,
A wild raging river
so far underground.

I tied me a string
and I left it that day.
I'd follow the string
till I found the way.

Not a word of the river
I breathed to no one
I'd go there alone
watch the wild waters run.

My childhood flew by.
I grew to a man.
Fell for a woman.
Put a ring on her hand.

But she didn't love me.
Started running around
Then I thought of the river
so far underground.

So into the cavern
we strolled hand in hand.
I came out alone
the way I had planned.

O'r the roar of the river
I heard her sad cry
In the water that echoes
but never runs dry.

I was tried for murder
but set free to go.
They had no proof
There was nothing to show.

I'm free but still guilty
and I miss her so
And today I'll go join her
where the wild waters flow.

Stanley harkens from the limestone hills of the Virginia, a terrain we'll explore in chapters to come. One might agree with a review of the song, however.

> *Wendy Smith's "River Underground" is haunting... but while the band does its best to infuse the material with some energy, notably through inspired backup work by Skaggs, Cline and Whitley (on lead guitar), they keep bumping up against the limits of worn-out melodies and more than occasionally pedestrian lyrics.*

A few pop music underground rivers, cropped for reason of space.

Talking Heads "Once in a Lifetime" Album: Remain in Light	*Letting the days go by / Let the water hold me down* *Letting the days go by / Water flowing underground* *Into the blue again / In the silent water* *Under the rocks and stones / There is water underground.* *Letting the days go by / Let the water hold me down* *Letting the days go by / Water flowing underground* *Into the blue again / After the money's gone* *Once in a lifetime / Water flowing underground.* *Same as it ever was. / Same as it ever was.*

Phish "All Of These Dreams" Album: Round Room	*You might find a river under a mountain That feeds a remote, subterranean fountain. Drink from this taste just a hint of a dream That some how leads in to the underground stream.* *And if you go there, and after you do All of these dreams would be yours to pursue. The rest of your lifetime, devoid of a care If you keep your eyes open, you may find yourself there.*
Thinking Plague "The Underground Stream" Album: A History Of Madness	*All my life I've been searching For the reason that my heart is broken. One day soon waters come Wash away what is done Some day floods will rise Wash this stain from our eyes* *Deep in the gorges, in the grottos, Time holds the antidote. Hubris is the triggering wire. We should be as water, Lower than all things. Yet stronger even than the rock*
Esther Frances "Underground River" Album: Mother Earth Calls	*There's an underground river deeper than the sea, An underground river eyes cannot see. An underground river deep and wide, Underground river where parts of us hide.* *Find your inner river journey to the sea, Find the One Life playing many parts as you and me. Compassion can then flourish rise up by going down, To that underground river 'neath each nation and each town.*
Benny Hester "Underground River" Album: Personal Best	*Underground river, Flowing through your city. Taking lives, breaking lives, sweeping lives Into an underground river. And the rain is pouring,* *The level is rising. And the white washed walls Scream as they fall. Nothing stops the river. No, nothing stops the river.*
Wire "Three Girl Rumba" Album: On Returning	*Painted statues in underground streams With invitations to the Pharaoh's dream. They stare at themselves, there's a need to be seen, Walking mirrors in the Pharaoh's harem.*

Ellen McIlwaine "Underground River" Album: Fear Itself An homage to Jimi Hendrix performed at Woodstock the year before the big one	*Was he really there at all?* *Or was it just a call* *That I heard from a hollow hall?* *Whispering his name* *May bring me down in the water* *To drown.* *Will I ever see his face again?* *Could I just pretend* *That this tunnel never ends?* *Keep memory of his face* *In my underground river* *Secret place.*
Mel Tillis and Nancy Sinatra "Underground River" Album: Mel and Nancy	*Then the underground river flows to the top,* *Deep and wide and impossible to stop.* *When the feeling in my blood rises like a flash flood,* *I'm a lover, a taker and a giver* *Flowing down that underground river.*
Irma Thomas and David Egan "Underground Stream" Album: Simply Grand	*Sweet, sweet water* *Give the sons and daughters.* *Bless it like the flowers that drink* *From the underground stream.*
Antler "A River Underground" Album: Nothing That a Bullet Couldn't Cure	*There's a river underground* *A river underground* *It runs between the stones without a sound* *There's a river underground* *Just beneath the ground* *But the desert's all that you an see right now*
Michael Garfield "Underground River" Album: Double-Edged Sword	*I'm a rounded stone in a trickling stream.* *A glowing coal enwombed in ashy bedding.* *Erode away my name and face,* *My time and space to deeper places than I've given you.*
Arlo Guthrie "Underground" Album: Outlasting The Blues	*There's a river running underground* *That rolls along the clay* *That took my body when I laid it down* *And carried it far away* *It's too damned dark for you to see* *So I did not protest* *My soul shook free, you can't have me* *But you may keep the rest* *The waters weep, the sickles reap* *My hands are cold with sweat* *The eagle screams with frightened wings* *The dust does not forget* *There's a river running underground* *That rolls along the clay* *That tempts the soul to the ocean cold* *To with the body lay*

Agnes Stone "River Underground" Album: Agnes Stone	*She knows, when everything is good There's a river underground She knows, when it comes to love There's a river underground She's the river in me Everything seems so fragile Could all come crumbling down Like ashes to the wind They won't stick around All I know is talking never did no one good Covers up the feelings that are real The river underground*
Subterra "Underground"	*There's a lot going on underground There's a world you don't even know about There's a river that flows into a sea There's an ocean of possibility I'm swimming upstream in a river that flows Through the underground sea The sea of love There's a lot going on underground*
Rufus Wainwright "Between My Legs" Album: Release the Stars	*When the rocket ships all fall, and the bridges, they all buckle And everybody's packing up their station wagons There's a number you can call, like a breast that you can suckle And we quietly will exit as it all is happening again 'Cause there's a river running underground, underneath the town towards the sea, That only I know all about On which from this city we can flee On which from this city we can flee*
Thinking Plague "The Underground Stream" Album: A History of Madness	*Gone to ground, life seeping down, rivers rise. One day soon waters come wash away what is done (some day floods will rise wash this stain from our eyes) Deep in the gorges, in the grottos, time holds the antidote. Hubris is the triggering wire. We should be as water, lower than all things. yet stronger even than the rock*

Michael Garfield "Underground River" Album: Double-Edged Sword	*I'm a rounded stone* *in a trickling stream.* *A glowing coal enwombed in ashy bedding.* *Erode away* *my name and face, my time and space* *to deeper places than I've given you.* *Relax the gates.* *My love awaits to fold into your quiet depths and patient truths.* *To couple with the subtle grace that lives through you.*
The Scorpions "The Sails Of Charon" Album: Taken by Force	*Dark night, there is no light* *In the realm of the black magic man* *Soul's flight into the cold blight* *Of the destroyer's magic land* *Poor man, whose spirits are stronger* *They're the ones who will reign* *You're struggles are in vain* *Throw out your evil desire* *The dark king's kingdom is* *Made out of mire* *Keep on for the kingdom of light* *There is no darkness, there is no night*

The rock band Styx of course comes to mind, but there's so much more in the way of American underground river albums.

STYX
GREATEST HITS

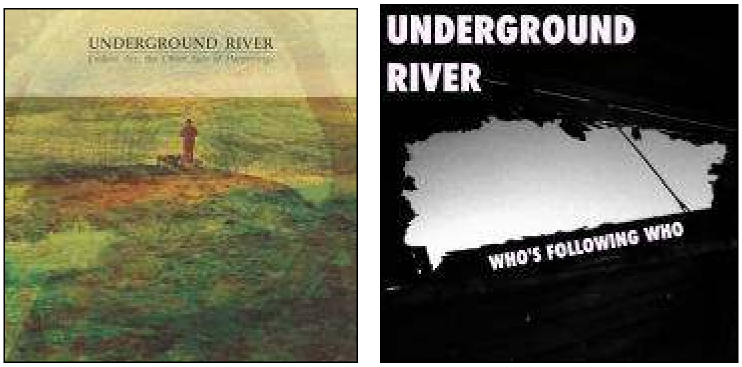
The triple platinum Styx

ACHERON
RITES OF THE BLACK MASS

Acheron, Satanic black/death metal

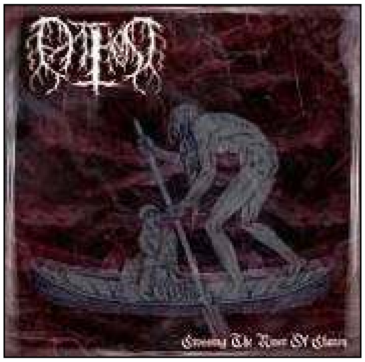
HAM1
THE UNDERGROUND STREAM

"The Underground Stream," by Ham1, pop rock


UNDERGROUND RIVER
UNDERGROUND RIVER
WHO'S FOLLOWING WHO

The band Underground River from Binghamton, New York

Underground river rock, international,

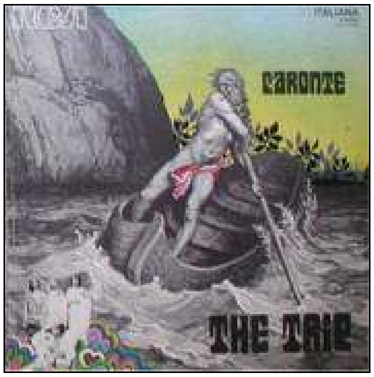


"Crossing the River of Charon" by Hellenic Black Metal Front from Greece

Υπόγεια Ρεύματα "Underground Streams" Greek rock and roll

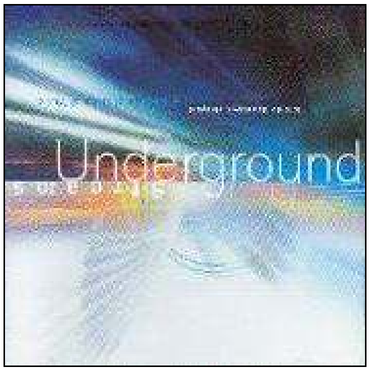
CHARON
SONGS FOR THE SINNERS

"Songs for Sinners" by Charon, Finnish gothic metal

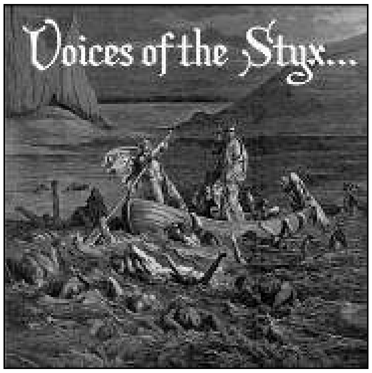


"Caronte" by The Trip, an English band that moved to Italy. The figure's again a Doré.

"Subterranean Streams" by Trimegisto, Chilean death metal



"Underground Streams" by Toronto Downtown Vineyard, contemporary Christian


Voices of the Styx...

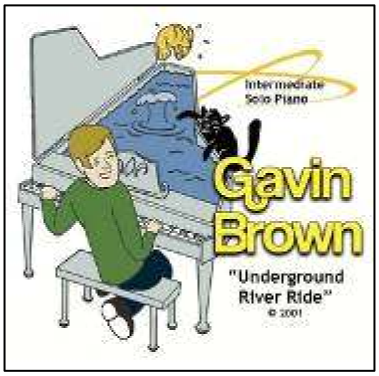
"Voices of the Styx," a Hungarian black/death compilation. The illustration's a Doré, Chapter 33

For those more into meditation and minimalism, ripples in the shadows, so to speak,

"Underground River" and "Underground River 2" on Michael Colquitt's "Still Waters"
"Underground Stream" on NON's (pseudonym of Boyd Rice) "Children of The Black Sun"
"The Underground River" on Paul Ellis' "Into the Liquid Unknown," piano with synthesizers
"Underground Stream" by Douglas Reed in Memoriam William Albright, Albright Organ Music

The intermediate to advanced pianist can try Gavin Brown's "Underground River Ride."

> *Imagine you're in a canoe paddling in a cave when suddenly a whirlpool sucks you down and you find yourself swept through odd caverns as a rushing underground river pulls you in one direction after another. Your lantern illuminates the strangely colored walls and you catch glimpses of strange eyes staring in your direction, but only for a moment and then they are gone.*



Whatever our musical taste, there's likely an underground river composition to suit.

CHAPTER 37

ACHLUOHYDROPHOBIA

We venture into the field of psychology, a quagmire of opinions where the subjective tends to trump the objective. What seems safest is to turn to the profession's famous names.

Freud and Jung

What we'd like is Sigmund Freud's and perhaps Carl Jung's interpretation of the psychological meaning of "underground river."

Freud visited the caves of St. Canzian (today, Slovenia's Skocjanske Cave, Chapter 72, Underground and Balkanized) in 1898. From his letter to Wilhelm Fliess, April 14 of that year,

> *The caves of St. Canzian, which we saw in the afternoon, are a gruesome miracle of nature, a subterranean river running through magnificent vaults, waterfalls, stalactite formations, pitch darkness, and slippery paths secured with iron railings. It was Tartarus itself. If Dante saw anything like this, he needed no great effort of imagination for his Inferno.*

We're severely tempted to thus apply a Freudian interpretation to underground rivers. A wet dark tube. How does this relate to our earliest associations?

But, no, we shouldn't go there. In the context of the letter, Freud's is a tourist account in the mode of the scores of the era's published travelogues. Of the several English translations of the letter, only one hints to some degree of horror, but even that isn't in the original German.

So how about Karl Jung and underground rivers?

From The Life Below the Ground: A Study of the Subterranean in Literature and History (1987) by Wendy Lesser,

> *Jungians are interested in the continuity of metaphor over time, and are therefore, like myself, attracted to the repetition of a single image in various cultures and periods. The Jungian psychologist James Hillman has pursued this technique in The Dream and the Underworld, an exploration of the idea of death in dreams, in myth, and in the literature of psychology. For Hillman, there is only one meaning to the underworld metaphor, and that is death; all of the various shapes which this image takes are merely the shadowy signposts pointing toward that deepest reality.*

It doesn't take a Jungian, here. Hillman's picking up on the death allusion we encountered in Chapter 28, Et In Arcadia Ego.

Lesser goes on to propose an additional interpretation of underground waters, however.

> *Another motif that seems to run through all underground children's books is the subterranean sea or lake. This occurs in Alice, of course, in the form of the Pool of Tears from which she is "born" (through that too-small door) into the world of "adult" playing cards and eccentric animals. Elsewhere it is not so dearly an amniotic pool combined with life-generating ocean, but I think its vestigial appearance in every children's story I've mentioned here has something to do with this original function. In The Adventures of Tom Sawyer it is "a subterranean lake...*

> *which stretched its dim length away until its shape was lost in the shadows"; in* The Silver Chair *it is a sunless sea, a seemingly endless expanse of "smooth, dark water, fading into absolute blackness," on which the children sail to the underground palace. This is a familiar image in adult underground works as well: think of the sea on which Jules Verne's underground travelers sail, or the River Styx across which Phlegyas ferries Dante and Virgil, or Dante's sea of tears. But whereas the' image is associated with death in those works, it tends to be associates with birth and rebirth in the children's books. For instance, the two children in* The Magician's Nephew*... repeatedly enter new worlds by jumping into various pools. In children's books, the hidden sea buried deep in Mother Earth can be a frightening place, but it is just as likely to be a useful passageway to a new existence: children, that is, do not seem to fear regression to the womb as much as adults do, nor to equate such retreat exclusively with death.*

We're familiar with the references to juvenile literature from our chapters on the topic and probably agree that more children see the plots in relation to growing up, not death. Lesser's "sunless sea" allusion is a nod to Coldridge (Chapter 30, Down to a Sunless Sea).

Freud and Jung simply didn't apply the full extent of thier insights to the topic of underground rivers. Such a shame, we note, as there's so much more to such rivers and the human mind. We just need a name, preferably a formidable one.

Achluohydrophobia

Fear of the darkness is rarely a fear of the absence of light itself, but fright at possible or imagined dangers concealed by the shadows. Rational fear produces caution and alertness for natural dangers, from tripping over something unseen to being attacked by a nocturnal animal.

Phobias fall into three categories:

Agoraphobia	Fear of places of assembly, crowds and open spaces
Social phobias	Fear of being observed doing something humiliating
Specific phobias	Fear of animals (e.g., spiders, rats, and snakes) Fear of inanimate objects (e.g., darkness, heights, enclosed spaces) Fear of illness (e.g., injury, death, disease)

Thus we're dealing with a specific phobia of an inanimate object, code 300.29 in the DSM-IV.

Sigmund Freud considered the fear to be a manifestation of separation anxiety. While most children experience some fear of the dark -- rarely before age two, however -- such fear usually doesn't rise to the level of paranoia.

In the 1953 Encyclopedia Britannica short film "Don't Be Afraid," Billy learns that fear of the dark is natural and enables us to avoid danger.

Announcer: *Billy's mother didn't know the real reason he didn't want to go to bed. When he was left along in a dark room, he became frightened.*

Mother: *Tell me, Billy, are you often afraid like this?*

Billy: *Not this much.*

Mother: *Well, I'm sorry you didn't tell me about this before. You should never be ashamed of telling me when you're afraid of something. Fear is nothing to be ashamed of. Everybody is afraid of something or other. Very Natural.*

One could provide young Billy the American Psychological Association's findings regarding his condition, but they're what any mom would know.

A bit more contemporary is the chorus from Iron Maiden's "Fear of the Dark."

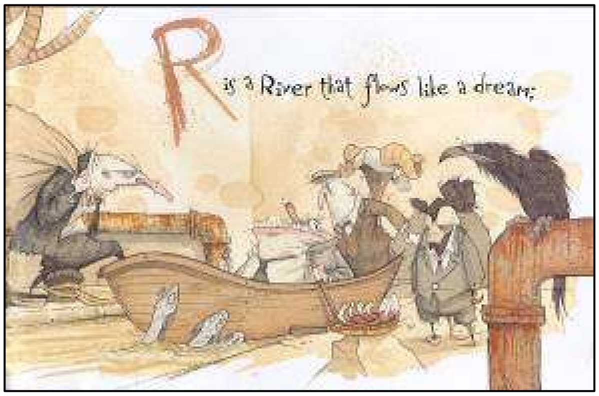
> *Fear of the dark, fear of the dark,*
> *I have a constant fear that something's always near.*
> *Fear of the dark, fear of the dark,*
> *I have a phobia that someone's always there.*

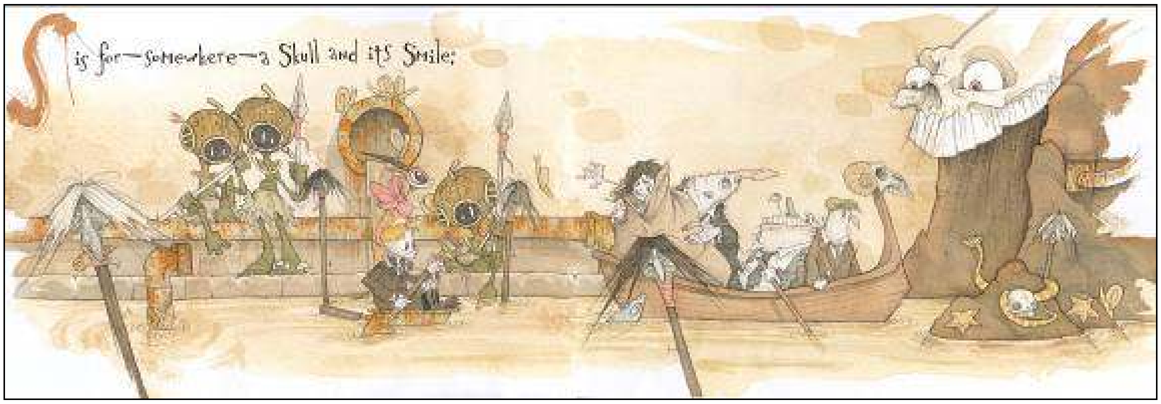
From where do such thoughts stem?

For a start, we need only visit the children's section of our local library.

In The Dangerous Alphabet (2008) by Neil Gaiman, two children and their pet gazelle treasure hunt along a sepia-toned Dickensian underground river surrounded by monsters and villains.

The young reader may or may not gain alphabetical skill, but surely ends up with a morbid concept of subterranean waterways.


R is a River that flows like a dream:


S is for—somewhere—a Skull and its Smile:

There are numerous theories of the psyche, but we'll just hit a couple.

From "Recapitulation and Education," The Pedagogical Seminary, A Quarterly International Record of Educational Literature, Institutions and Progress 7, 1900, by Cephas Guiiabt,

> *Sensibility to light is rare among the protozoa, but general among the metazoa. As a rule the lower animals prefer the dark, while the apes are almost without exception diurnal animals, and we have even some evidence that they are afraid of the dark. The child at first shuns strong light, but this, like many other early reactions, seems to be due rather to the delicate sensitiveness of the unaccustomed nerves than to a feeling of fear. He soon shows for it a strong interest, which seems very like fascination, due doubtless to the mixture of pain and consequent fear still present. This fascination for a bright light is quite prevalent among the vertebrated animals. Later on, some children show fear of the dark, but whether this is innate or due to suggestion does not appear.*

And from "Children's Fears," the same journal, Volume 28, 1921, by Henry S. Curtis,

> *The fear of the dark is an almost universal fear, although the child tucked in his bed at night is almost absolutely safe; far safer than at any other time, and is only threatened by fire, of which he is usually not afraid. Many say that this is an artificial fear which has been given the child through the terrible stories which have been told him. It is doubtless possible to bring a child up in such a way that he will not fear the dark. Nevertheless, it only takes a very slight occasion for this fear to appear, thus showing a natural tendency. If it is prevented, it must be by the use of much caution. The reason for this fear is obvious. All instincts develop as such only through the habits and daily life of the race, followed through generations of time, consequently all instincts and emotions are adapted to ages long back in racial history. There was a time when the dark held all the monsters which the child's imagination yet beholds, when the lion and the tiger, and the cave bear, and yet more savage man, lay in wait, and did their hunting in the dark. After the day has gone, and the darkness comes upon us, the nervous system still vaguely feels their dread.*

As psychology has since become a theme of glossy magazines, we can go to newsstands for updates.

"Hydrophobia" has two meanings:

> The fear of water, an anxiety, potentially pathologic. Symptoms include nausea, sweatiness, disorientation, loss of control and panic attack.
>
> An older term for rabies (Latin for "madness"). Because of this name, many believe that rabies makes one afraid of water, but that's not so. Victims of rabies get spasms in their throat muscles that prohibit drinking, and so will refuse water.

Fear of underground rivers could thus be called:

> Achluohydrophobia from the Greek root "achluo," dark
> Nyctohydrophobia, from "nukt," night
> Scotohydrophobia, from "skotos," darkness
> Lygohydrophobia, from "lyge," twilight

As we're coining the term, the choice is ours and "Achluohydrophobia" nicely alliterates with "Acheron," the river of Hades. "Hydroachluophobia," we surmise, would be the fear of watery darkness, rarely a concern to two-year-olds.

We saw evolutionary achluohydrophobia in Chapter 33, Twenty-Five Centuries of Subterranean Portraits. In his formative years, Charon indeed dealt with death, but his portrayal would not have struck terror. Though the Christianized Charon took on Luciferian aspects, the pointed ears and snake-like tail were of God's design, a cautionary prod for righteous lifestyle. Only in the past century have the depictions degenerated to little purpose above that of horror.

We need but skim Chapters 29-31, dealing with metaphor and poetry, to catch the literary despondency associated with subterranean waters.

Q: Where did James Dickey fearfully peer in search of his unreconciled and departed sibling?

A: Into the underground river.

Q: Does the thought of an underground river likewise evoke within us an anxiety?

A: Freud would argue to the affirmative, both from the aspect of darkness and as a manifestation of our yearning to return to the watery womb.

Q: We will not dispute that the concept of a subterranean stream whispers to our unhappy side, but is the depth of achluohydrophobia our only latitude when confronted with such waters?

A: Of course not. The rest of the chapters are much longer than this one because there's a great deal more to our world than phobiology.

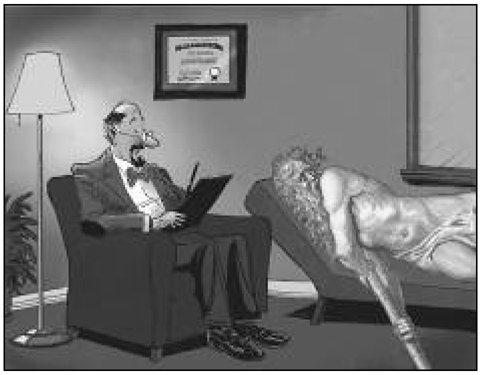
Let us propose an alternative term, "Achluohydrophilia," a fondness for underground rivers. If nothing else, it's upbeat.

Q: Do those of us who ponder underground rivers require psychoanalysis?

A: Some may say so, but we think not.

Q: Might Charon benefit from professional help?

A: Indeed, he might. He looked upon his mother as a Greek goddess, after all.



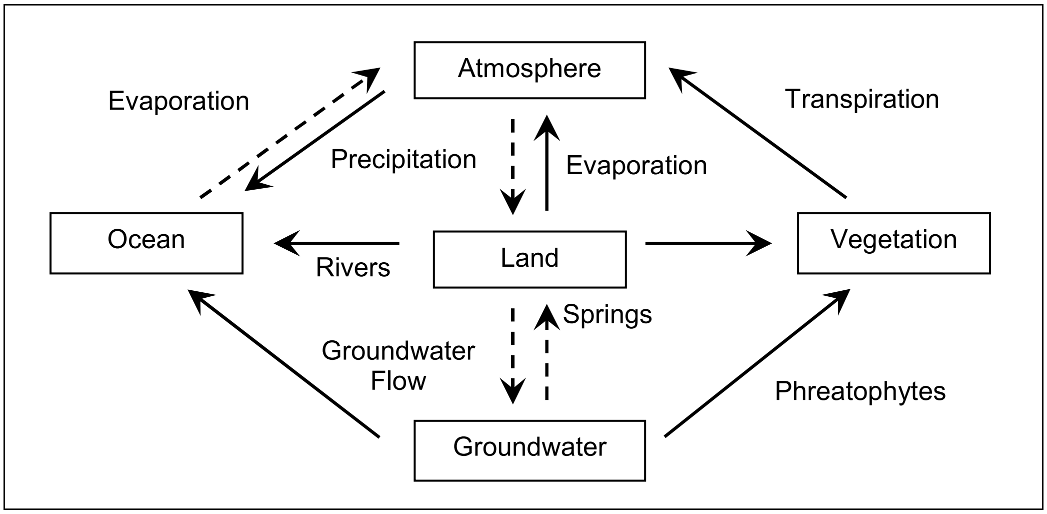
CHAPTER 38
HYDROGEOLOGY

Following is an estimate of the earth's water resources.

	Cubic km
Rivers	2,000
Atmosphere	13,000
Soil moisture	16,000
Saline lakes and inland seas	100,000
Fresh water lakes	125,000
Groundwater to depth of 4000 m	10,000,000
Icecaps, glaciers, permafrost	29,000,000
Oceans	1,325,000,000

North American groundwater uniformly distributed over the continent would make a lake nearly 30 meters in depth. As subsurface water must fit into the pores between soil grains and rock fractures, however, a greater saturated soil depth is required to store this water, in the order of 100, 300 or 1000 meters for sand, shale or limestone, respectively.

To this point in our journey, we've seen a number of hypothesized hydrologic cycle schematics. Following is a simplified rendition of the correct answer.



The only ocean-to-springs route -- the four dashed arrows -- passes through the atmosphere.

Much more water is stored under the ground than in rivers, 10,000,000 cubic kilometers to 2,000, but surface flow is said to deliver 20 times more to the sea than that which travels beneath the shore. "Is said to deliver," however, is just an "is said to." According to R. Monastersky in "Seep and Ye Shall Find: Hidden Water Flow," in Science News, April 30, 1996,

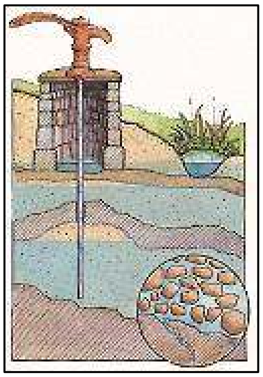
> *Before these new measurements, some scientists had suggested that groundwater flow into the ocean might equal only one-thousandth of the river flow. But Burnett estimates that groundwater contributions to the ocean total about one-tenth of the amount supplied by rivers globally. In some locations, the groundwater component may dominate, he says.*

Perhaps the safest thing to say is that underground rivers probably don't deliver a proportionally great amount to the sea, but we're not that certain how much.

The One-Thousandth Rule of Thumb is woefully approximate, but reasonably suggests the relative magnitudes of groundwater flow vs. surface water flow.

Groundwater velocity is in the order of one-thousandth that of a surface stream.
The width of a groundwater passageway is in the order of one-thousandth that of a surface stream.
The height of a groundwater passageway is in the order of one-thousandth that of a surface stream.
As discharge is the product of velocity and cross-sectional area,
Groundwater discharge via a particular subsurface pathway is thus in the order of one-billionth that of a surface stream.

The velocity of the Amazon is in the range of 0.7 meters/second. At high stage, the Mississippi flows at about 2.4 meters/second. (A brisk walk is mid-way between the two.) Most groundwater, on the other hand, is traveling orders of magnitude more slowly. Most water wells draw flow at almost an imperceptible velocity through the miniscule interstitial voids of a large surrounding area.



There may be large volume of groundwater under our feet, but in terms of discharge, it takes a perhaps a billion subsurface threads to equal what most of us envision to be a "river."

We will have much to say regarding calculations in Chapter 43, The Hydraulics of Underground Waters.

Aquifers

Aquifers are porous geologic strata from which water can be economically extracted. Aquifer is judged by,

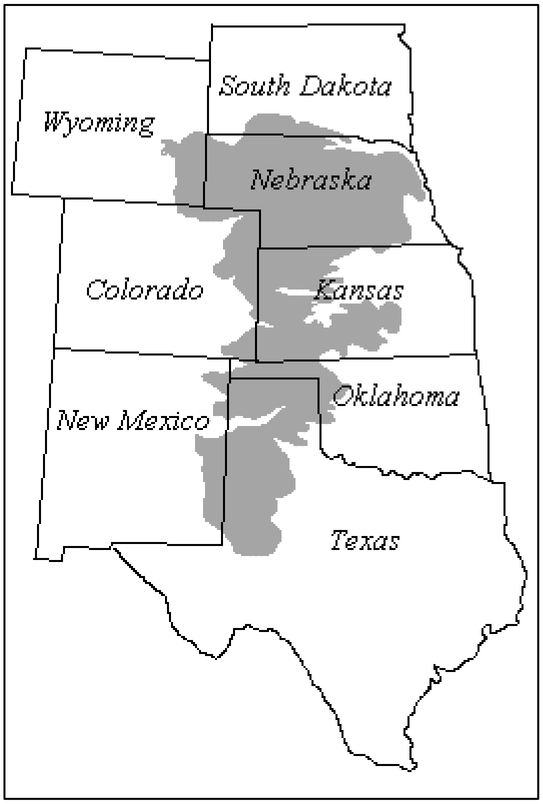
How much water is contained within the pores, and
The strata’s capacity to transmit that water.

Most aquifers were never themselves above-ground rivers, but rather once were broad zones of terrestrial surface, lake bed sea floor which accumulated silts, sands and rock fragments over eons. The passing millennia may have resulted in compaction and consolidation, but connected voids yet remain between the particles.

Unconfined aquifers are those without a fixed top boundary. The water level (the “water table”) can rise or fall with recharge or pumping. Think of a large sandbox.

When the popular press deems a story regarding groundwater to be newsworthy -- not as often as it should, we maintain -- too often "underground river" or "underground lake" is used in lieu of "aquifer." As virtually all aquifers are wide and quiescent, "underground lake" is perhaps the less incorrect, but we'll avoid misrepresentation entirely and call an aquifer an aquifer.

An example is shown on the right, the Ogallala Aquifer consisting of unconsolidated, poorly sorted clay, silt, sand, and gravel. As there is generally no impervious layer above these deposits, the aquifer is unconfined. The aquifer holds nearly 3,700 cubic kilometers of water, a decline of roughly 10 percent since large-scale irrigation began in 1950s.



The Ogallala was laid down about 10 million years ago by fluvial deposition from the Rocky Mountains. As subsequent erosion has removed the deposits between the mountains and the Ogallala's western boundary, there is no longer recharge from the Rockies. Recharge from local rainfall and snowmelt is roughly 3 cm annually for the aquifer as a whole.

Depth to the water table varies from almost 125 meters in the northern plains to between 30 and 60 meters in the south. Corresponding saturated thickness ranges from more than 300 meters to between 15 and 60 meters. Typical groundwater velocity is in the range of 1 meter/week. The Ogallala is doesn't flow like a river.

But rather than simply declare the scientific facts of things -- which given the progress of scholarship, too often turn out to be not quite the facts -- we'll look the journalism, in this case, the Fort Worth Daily Gazette of August 3, 1890. An inquirer raises a question regarding the aquifer east of the Ogallala, the Edwards aquifer, of which we'll again speak in Chapter 79, Veins of the Heartland. The Daily Gazette's plain-talk response is reasonably correct.

> *Our Underground River. I was deeply interested in your late article on the great artesian well area stretching across the State of Texas from about Denton to Laredo. No doubt, as you predict, this important discovery made by our geologists will eventually cause the area pointed out to be converted into a grand agricultural region, sure enough. It covers our very best agricultural lands which have heretofore been held back from fullest development on account of imperfect water supply only. But there is one thing in your article that I do not clearly understand though doubtless you can explain it all easily enough. You speak of this remarkable artesian area as being above a great underground river. If this be so, whence comes the water of that river and why does it not at some point find its way to the surface and there cease to be an underground river? Why should Texas have great rivers underground and but comparatively insignificant rivers on the surface? -- A Thinker, Fort Worth Tex*
>
> *The foregoing was evidently intended for our "answer to correspondents" column, but feeling a desire to answer it at greater length than space in that department would consistently permit, we have concluded to give it a hearing here.*
>
> *What we figuratively called an under ground river is of course no river at all. Professor Robert T Hill says it is more like a great saturated sponge or rather a series of great saturated sponges. These "sponges" (the water bearing strata) are composed of coarse sand and pebbles lying between strata of stone impervious to water. In a word, there is a deposit of sand and pebbles which for convenience we may term the lower water bearing stratum. It is continuous from the head of the artesian urea described last week, to where Texas loses interest in the area by its passage from her territory at the Mexican line. Above this stratum lies a thick stratum of stone that water cannot pass through. Next, on top of this comes another*

> *water-bearing stratum of sand and pebbles, then another stratum of stone and so on until the five or six water-bearing strata as lately worked out by Professor Hill are made up*

For another example of the casual usage of "underground river," and the like, for what's simply a porous-media aquifer, we can open Kansas: A Cyclopedia of State History (1912), edited by Frank Wilson Blackmar.

> *The U.S. government made investigations in western Kansas that led to the discovery of an underflow of the Arkansas that amounted to practically a subterranean river. In 1905 it installed at Deerfield, in Finney County, an irrigation plant that pumped water from wells drilled to this underground stream.*

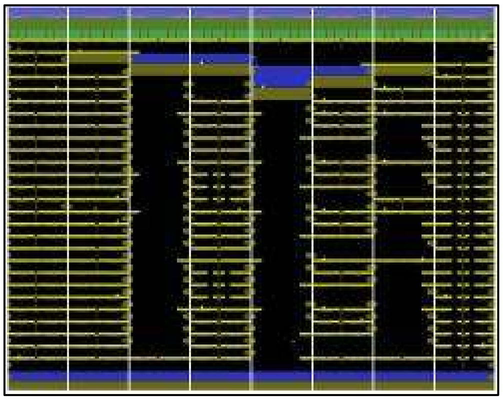
Where the Allegheny and Monongahela meet the Ohio, long-time Pittsburghers say that there's another river flowing below.

The proper name of this "underground river" is the Wisconsin Glacial Flow, its size varying from one to three kilometers in width and 5 to 12 meters in depth, forming an oval tunnel completely filled with rocks and gravel.

The bed and banks of this formation were carved when the Ohio and Allegheny rivers flowed northward to the St. Lawrence. When the outflow was blocked by glaciers, the beds filled with gravel, southward exits were created and clay and silt sealed the old channel from the surface above. Through this deposit, Pittsburgh's underground river flows at the remarkable rate of 10 kilometers/day.

Pittsburgh's underground river differs from other aquifers in that it's not widespread and follows a defined channel.

The most visible evidence of Pittsburgh's fourth river is Point Park Fountain which spews water pumped to the surface.



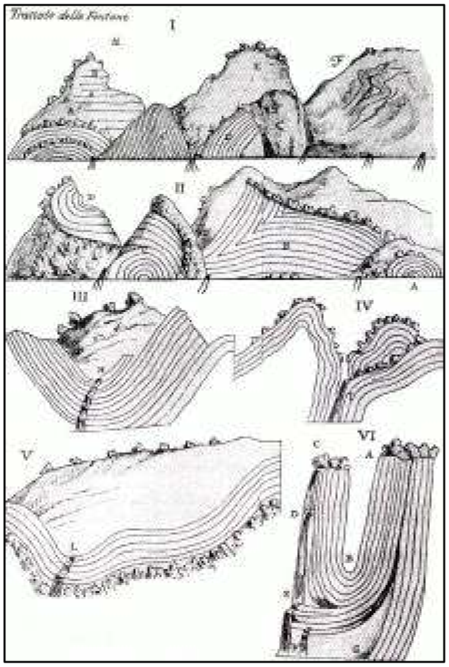
Perched aquifers are unconfined aquifers trapped above unsaturated media by an impermeable dish-shaped stratum.

We discussed video games in Chapter 27 -- a far cry from geology, some might claim -- but we can employ a Pitfall III subterranean screenshot to illustrate the definition.

The water trapped near the top-center is perched. The water in the lowest level is not.

Confined aquifers are those where an impermeable overlying strata holds the aquifer under pressure. Think of a large sandbox with a sheet of plastic buried half way down. Insert a hose into the bottom layer, turn on the spigot, and it's a confined aquifer. How could we prove it? Punch a hole in the plastic and watch the water leak upward.

For a Northeastern Italian today, an Alpine excursion is a common weekend option. Three hundred years ago, however, mountains were considered to be ungodly places, blots on Creation. But biologist Antonio Vallisnieri (1661-1730) saw the geology as a window into the earth. The only cross-section of folded strata earlier than Vallisnieri's Lezione Accademica intorno all'Origine delle Fontane (1715) was by da Vinci.

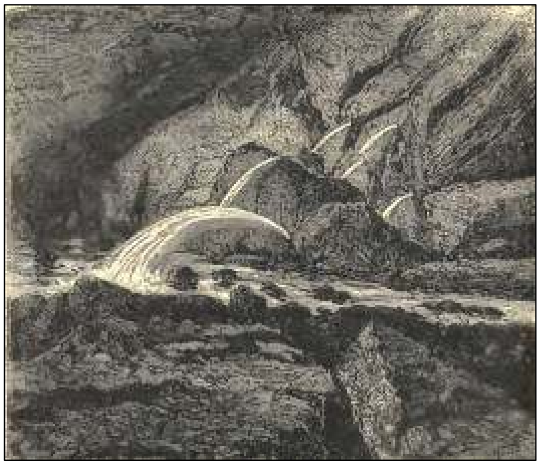


Above the tree line, Vallisnieri encountered "grottos, abysses, declivities, cracks, great valleys, caverns, trenches, ponds, gorges, craters, precipices with many basins and receptacles," sites in which water collected from the uphill "eternal reservoirs" of ice and snow did not appear to be released. Vallisnieri concluded that the snow, rain and condensed mist near summits filters downward through permeable sand, loose rock and earth until blocked by impermeable clay or solid stone.

> *The rain water* [is carried] *down into the interior of the mountain whence it passes away in subterranean channels.*

Noting springs fed by strata dipping down and then turning upward, he recognized that pressurized water was following a confined pathway. Water disappearing into rock fissures in the Apennines must be the origin of the artesian wells of Modena. Likewise, recognized Vallinniere, the Muota River in central Switzerland must be fed from springs supplied from sinkholes in the surrounding hills.

A graphic, albeit exagerated, illustration of artesian springglow comes from Elisee Reclus' The Earth: A Descriptive History of the Phenomena of the Life of the Globe (1871).



"The Saline Springs of Touzla"

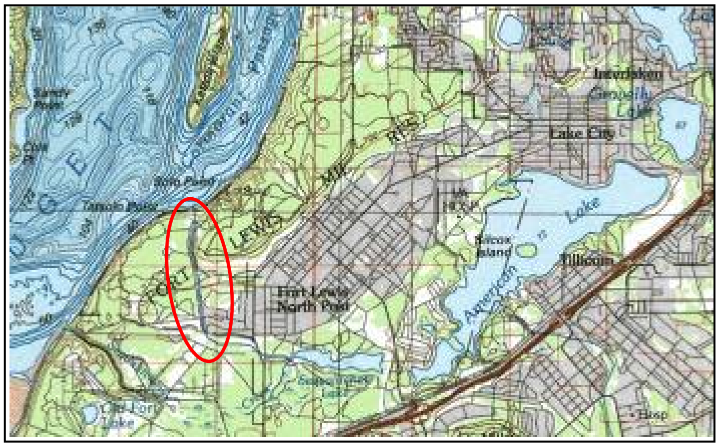
Even a rudimentary understanding of strata can at times help resolve what seems to be a perplexing account. As will become more and more obvious in the chapters to come, newsprint of a century ago tended toward embellishment. Take, for example "Roaring Underground River," a report from Washington state in the March 9, 1896, Omaha Daily Bee.

> *Browder D. Brown, who returned seven days ago from a trip through the country south of Lake Park, reports on an interview published in the Tacoma Ledger, that an underground river has been discovered o the farm .of John Hanson, a Swedish farmer, six miles south of Lake Park. "It is the first underground stream I over saw," said he, in describing it, "and is quite a curiosity." It was discovered some time ago. Hanson and his neighbors were digging a well at a depth of fifteen feet they began to hen a strange roaring sound. The diggers became frightened, but continued their work. At twenty feet the earth broke through, revealing a swiftly running subterranean stream. The water tastes much like the ordinary well water found in that region.*
>
> *The roaring of the water can be hear a distance of fifty yards from the top of the well. The day I was at the farm no one was present save a small boy, Hanson's son. All he could tell me about the river was that it ran faster and roared louder in winter than in summer. The water runs unusually swift and the incline of the river-bed at the point I saw it must have been quite sharp. Hanson has an old fashioned, oaken bucket and a box rigged up over the well. He lost the first bucket he put in and was unable to recover it. He pays but little attention to its singing. The course of the river at Hanson's appears to be in the direction of American Lake. It is my opinion that it flows into that bed of water, passes through it and flows then underground to the Sound. As is well known, American lake has no visible outlet. The source of the subterranean stream is probably in the foothills of Mount Tacoma.*

As a century of subsequent well drilling reveals no such underground river, was the account thus a total fabrication, a ploy to hawk Omaha newspapers?

Perhaps not totally, given recent hydrogeologic assessment at nearby Ft. Lewis.

American Lake today has a visible outlet, the drainage canal within the red oval to the right, but before it was excavated, the terrain was marsh through which an observer might not have recognized a flow path.



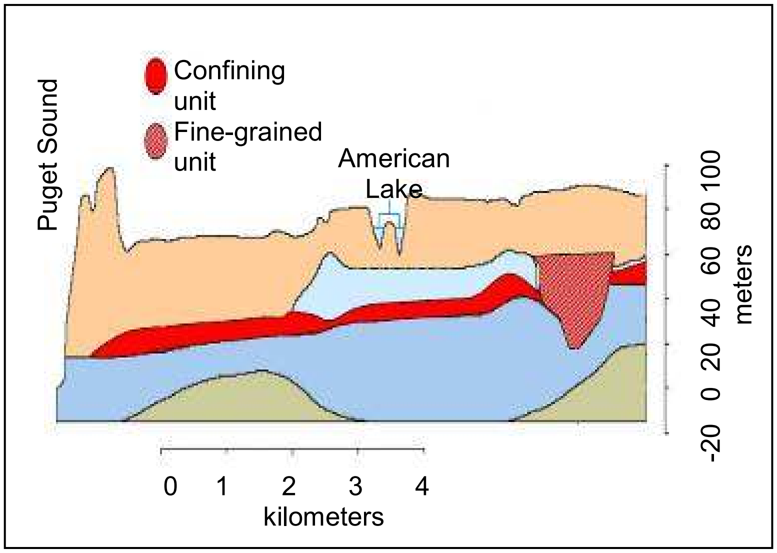
So what might have John Hanson, the Swedish farmer, encountered?

To answer that, we'll look at the geology.

The cross-section shows a confined aquifer pressurized by lake surcharge.

As the strata are comprised of glacial and non-glacial sediments, an underground conduit is most improbable, but the confining unit might overlie pockets of unconsolidated gravel. The "singing" might have been the clatter of its adjustment after disturbance.

As for the lost oak bucket, it's probably yet at the bottom of the shaft.



If a sufficiently-pressurized confined aquifer is punctured, water can spout above the land surface, creating an artesian well, so named from the flowing well dug by monks in Artois France in 1126.

As with unconfined aquifers, velocity in confined strata is far less than that of surface flow. A constricted exit, however -- the artesian well in Rocky Ford, Colorado, pictured to the right, being an example -- can give the superficial impression of an underground vein.

Here's another example, "Subterranean Lake in Indiana," Brooklyn Daily Eagle, September 3, 1850.

> *Near the town of Williamsburg, Johnson Co., is what might be called a subterranean lake. A gentleman there digging a well, at about the depth of thirty feet, after passing through five or six feet of bluish earth, thought the earth sounded hollow as the mattock was driven into it. A small stick was forced downward six or eight inches, and on its withdrawal a stream of water gushed forth five or six feet in height. The man was immediately drawn out, and scarcely had he reached the surface when the bottom of the well burst upward, and a volume of water rushed out with great force. The water has a disagreeable odor, and is unfit for any purpose. Several pieces of rotten wood were thrown out. We have these facts from unquestionable authority.*

From the Scientific American, January 10, 1857,

> *A subterranean river has been struck by the persons engaged in boring an artesian well at Henderson, Ky., from which a jet of water is forced up through the bore, and thrown to the height of fifty feet above the surface of the ground.*

In 1886, the city fathers of Belle Plaine, Iowa engaged Willy Weir of nearby Monticello to water-witch the site of a new water source and Weir found Jumbo 60 meters below the ground.

Willy Weir's 5-centimeter hole blasted water 15 meters into the air, and Jumbo was quickly a 3 cubic meters/second geyser erupting out of a meter-wide crater. Reporters nick-named Old Jumbo the "Eighth Wonder of the World." A Paris newspaper published a cartoon of Belle Plaine submerged in Old Jumbo's water, with small children standing on roof tops calling for help.

Old Jumbo was still thundering at more than 0.1 cubic meter/second 14 months later when foundry-owner George Palmer tamed the flood a custom iron cone 1 meter in diameter and 8 meters long requiring,

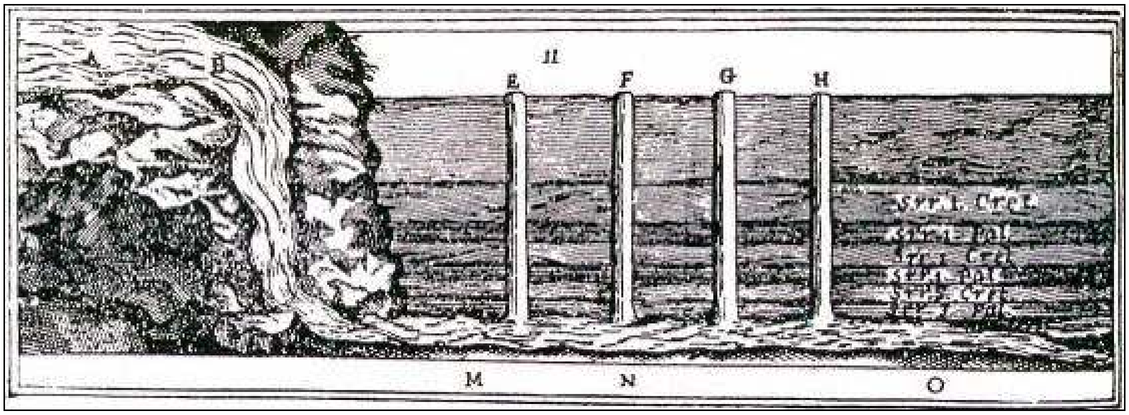
50	meters of 0.45 meter pipe
24	meters of 0.40 meter pipe
18	meters of 0.13 meter pipe
40	train-cars of stone
130	barrels of cement

A recent artesian claim from Afghanistan,

> *Of note are eyewitness reports in Kabul, of waterspouts rising from bomb craters immediately following impact. These points of impact are not situated close to public or private, water-works' infrastructure; they are reported to be natural springs and underground watercourses. In Bagrami, a farming community outside of Kabul, the bombs penetrated an underground river, causing a flash flood over several hundred hectares of crops and grazing land.* -- Field Team Report on Afghan Trip #2, Uranium Medical Research Centre (September/October 2002)

A mammoth upwelling only makes physical sense for an artesian aquifer (one in which pressurized groundwater is confined by an upper stratum, Chapter 38, Hydrogeology) near the surface, but un-breached naturally. Had a well been excavated, the upward flow would have likewise inundated the hectares, just not as quickly as via a bomb-size hole.

Ramazzini's (Chapter 7) 1691 illustration of artesian springs recognized the pressure relationship, but is unduly dramatic in its presumption of the subterranean channel. In reality, the water's percolating through a confined porous stratum.



Nathaniel S. Shaler's discussion of artesian wells in Outlines of the Earth's History, A Popular Study in Physiography (1898) was a bit more complex.

> *It may be well to note the fact that the greater part of the so-called artesian wells, or borings which deliver water to a height above the surface, are not true artesian sources, in that they do not send up the water by the action of gravitation, but under the influence of gaseous pressure... In all cases this water contains a certain amount of gases derived from the decomposition of various substances, but principally from the alteration of iron pyrite, which affords sulphuretted hydrogen. Thus the water is forced to the surface with considerable energy, and the well is often named artesian, though it flows by gas pressure on the principle of the soda-water fountain.*

The soda-water fountain analogy is bogus, it turns out, but imagination's always played a large role in underground river speculation.

Another example of unsubstantiated presumption comes from "Hydrographie Souterraine," Memoires de Academie des Sciences, Belles-Lettres et Arts de Lyon (1858) by Joseph Fournet.

> *Let us not forget that, as well as the layers of* [underground] *water which are known to exist here and there, artesian borings have shown the existence of very rapid currents flowing in unknown channels.*

Artesian behavior, however, is evidence of pressure not velocity.

And while we're dealing with erroneous explanation, readers of "The Artesian Well," Western Rural and American Stockman, February 22, 1894, were informed that while most artesian discharge is via an underground river from a higher elevation, some artesian wells are due to subterranean gasses, an mechanism somewhat Kircherian in nature.

> *The philosophy of the flow of water from artesian wells is generally known. No matter how deep in the earth the well may have been sunk to strike a subterranean vein or pool of water, one of two causes must operate to force a flow of water to the surface. One of these causes, and the most common, is the existence of a fountain or source of supply situated at a higher altitude than the point of discharge at the surface of the ground where the well is situated, and generally a long distance away. The other cause, as a whole or in part, is the expansive force of air and gases, which operating under the column of water to be forced to the surface, supplies the power needed to do the work which the gravity pressure from a distance and higher fountain head has failed to do.*

John Wesley Powell, oft cited for insight into water issues that would come to define the economic development of the American West, can be credited for a portion of the misinformation that has led to confused groundwater management. Here's a portion of his "Irrigation. History of Irrigation. The Extent of Our Arid Lands. How They Are to be Made Productive. The Water Supply," published in the Independent, May 4, 1893.

> *In addition to the perennial waters of streams, underground waters are utilized in various portions of the world. Wells from which the water is pumped are very common in some portions of Asia, where millions of people gain subsistence by bringing the water up and out of the earth and pouring in on the ground. Artesian waters are also used, perhaps more extensively in the United States than anywhere in the world. The supply of water from these fountains is usually small and limited, as it is accumulated in artesian basins, within which too many wells must not be sunk or the supply will be exhausted. From two to ten acres are sometimes irrigated from one artesian well, and there are a small number of wells in the United States that irrigate much larger areas. There is still another supply sometimes used in various portions of the world, and now being used to slight extent in the United States; this is found in the sands of flood-plain valleys that become saturated with water during storm seasons or by great river floods, and such are tapped for the water which they yield. The supply is narrowly limited ad its utilization rarely extensive.*

Powell's use of "artesian" appears to be broader than the meaning of today. He seems to suggest the narrow thread-like karst subsurface streams (the subject of the chapter to follow) with which he would have been familiar from his days in Ohio.

The water for which he saw little demand was in the "sands of flood valleys," what would turn out to be the vast alluvial fans on either side of the Rockies.

Maj. Powell did not foresee that American groundwater withdrawals would triple between 1850 and 2000, coming to serve 30 to 40 percent of American irrigation. National water policy, however -- as we will note in Chapter 63, The Law of Subterranean Streams -- is still trying to catch up.

Let us not second-guess the explorer too harshly, however. It would be decades before such nationally-influential periodicals as the Independent would begin to recognize the significance of the less-interesting water "found in the sands."

Powell went on to serve as the second director of the US Geological Survey, and in that capacity helped formuate national policy regarding development of the the arid West. We quote two documents in which Powell did his best to correct popular misconceptions regarding "underground rivers" of that zone.

> *When streams disappear in this manner, never to appear again at the surface, it is often popularly supposed that underground rivers exist, but there is no foundation for this popular error, as it is well known that the rivers are caught by the sands and evaporated, a sand plain constituting a more efficient evaporating surface than a body of water. These streams which do not roll on to join others are in the West known as "lost rivers," and Director Powell calls the natural districts which they constitute "lost-stream districts."* -- Report of the Special Committee of the United States Senate on the Irrigation and Reclamation of Arid Lands (1890)

> *There is a popular belief that there are many underground rivers of this character in the dry regions of the far West. In all regions there are underground waters, as the loose soils, sands, and gravels retain much water; and the sands at the mouth of a vanishing stream also contain more or less subterranean water of this character, which is more slowly evaporated into the heavens; but these so-called lost rivers, carrying waters from mountain streams of arid regions, do not exist, and the popular error in this respect has no foundation in fact. Yet there are lost rivers of another character, where streams disappear from the surface and run in underground channels, to reappear below.* -- The Physiography of the United States (1896)

American hydrologist R.E. Horton's "Idiosyncrasies of Ground Water," Proceedings, Connecticut Society of Civil Engineers (1915) disputed the prevalent belief that many wells were "inexhaustible" because they are fed by rapidly flowing "underground rivers."

For eight months of the year, Australia's Gascoyne River slowly seeps below its dry bed. As the water's under the alluvium, the watercourse's 760-kilometer length merits some sort of underground record. That in such conditions it's still a "river," however, is debatable.

World Record

Longest Sub-Alluvial Watercourse
760 km

We'll remain open-minded regarding "river" terminology for aquifers, however, and not get uppity in the manner of Samuel Sanford in The Underground Water Resources of the Coastal Plain Province of Virginia (1913).

> *The belief held by many persons that underground waters in places outside of limestone regions lie in lakes or move as rivers, has little foundation in fact. The lakes and streams reported by well drillers are merely beds of saturated sand. The rivers described with great particularity by some water finders often are pure fiction, the stated course of an underground river having no relation whatever to the geology of the district.*

As we must occasionally remind ourselves, we're looking at what people call "underground rivers," not just what the experts deem proper.

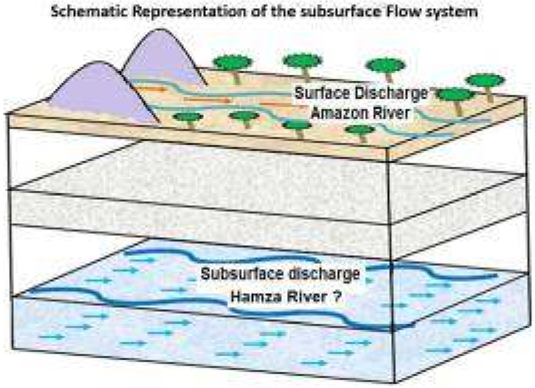
The Rio Hamza

It surely was the fourth and fifth words of the title "Indications of an Underground River Beneath the Amazon River: Inferences from Results of Geothermal Studies" by Elizabeth Tavares Pimentel and Valiya Hamza, presented at the 12th International Congress of Brazilian Geophysical Society, August 17, 2011, that propelled the story to newspapers and social media web sites worldwide. Typical headline: "Scientists Believe Brazil has Huge Underground River," Irish Times, August 27.

The Brazilian scientists identified a "Rio Hamza" (named for the senior investigator) flowing from under the Andes to the depths of the Atlantic by applying the principle that water flowing through rocks causes anomalies in the dispersal of geothermal heat to temperatures in 241 inactive oil wells drilled in the 1970s and 1980s. Analysis suggested that subterranean flow seeps vertically downward for about 2 kilometers and then horizontally along the basal layer 4 kilometers below.

A few comparisons:

	Amazon	Hamza
Length (km)	6110	6000
Width (km)	1-100	200-400
Velocity (m/s)	0.05-5	0.000000001 - 0.000000010
Discharge (m3/s)	133,000	4000



University of Bahia geologist Olivar Lima, who was present at the conference, noted that while the preliminary results appeared valid, more research would be necessary before the subterranean system can be classified as a "river."

Calling the discovery an "underground river" is indeed premature, agreed hydrogeologist Larry Murdoch of Clemson University in "Is underground Amazonian river really just groundwater flow?" Nature News, August 26,

> *"This sounds like an interesting study that could contribute to the understanding of groundwater in the Amazon Basin...* [But] *it would be worthwhile trying to explain the temperature measurements in the context of a conventional groundwater flow system before inferring the existence of a new underground river."*

As reported by BBC News, August 27, in "Subterranean Amazon River 'is not a River,'" Professor Hamza clarified the wording.

> *"We have used the term 'river' in a more generic sense than the popular notion... This is water flowing through porous rock, mainly sandstone and under that, conglomerate... Unlike a true river, this underground water flow has no fixed boundary."*

Jorge Figueiredo, geologist with the energy corporation Petrobras, was more to the point.

> *"The word 'river' should be burned from the work - it's not a river whatsoever."*

Had the scientific paper been properly titled "Indications of an Aquifer beneath the Amazon River: Inferences from Results of Geothermal Studies," there wouldn't have been press attention in the first place.

So how about an underground river of oil?

Such an idea seemed plausible to the Washington Post, as evidenced by the edition of March 5, 1922.

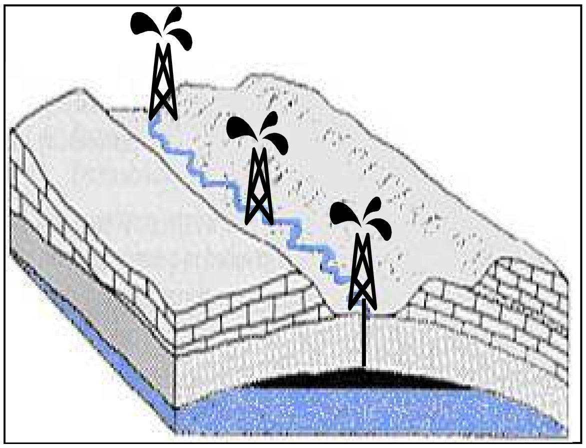
> *In Chiapas* [Mexico] *are pyramids which are "doting with antiquity, forgetting the names of their founders," and there is reason to believe that fires were maintained upon them, fed by everlasting streams of petroleum fetched from the bowels of the earth.*

Petroleum prospecting in the mid-1800s used the terrain surrounding a producing well to suggest where to next drill. If a well had hit oil on the side of a hill, they measured from the crest of the hill to the location and the base, then found hills of similar dimensions and drilled on a corresponding site. Other prospectors analyzed vegetation and took samples of the soil, attempting to locate oil by the effects a subsurface pool might have on the topsoil above.

Jeremiah Smith had another solution. As oil was found as far north as Nebraska and as far south as the Gulf of Mexico, these oil lakes must be connected by underground rivers. But as the face of America sloped to the south, oilmen would have to hurry, lest these underground conduits drain America's oil wealth into the Gulf. There was talk of attempting to find one of these underground rivers of oil and building a dam to impede its course, but as no one was sure a single dam would suffice and no one had actually found one of these rivers, Smith's theory likewise faded into oblivion.

Further theories arose based on that of Smith, and thus emerged the theory of "creekology," that an oil river would lie below a running stream.

Holes were drilled along watercourses, some successful, the dry ones forgotten. An 1878 U.S. Geological Survey publication detailing streams coated with petroleum, areas devoid of growth because of natural gas seeps and water that livestock refused to drink because it was tarry seemed to support this theory. Pointedly, however, the document dealt with petroleum reservoirs, not petroleum rivers.



The Oklahoma oil rush later dispelled any correlation of petroleum reserves with creek beds, but the name "creekology" stuck -- oil prospecting by associated landform.

We'll conclude our discussion of groundwater science with a citation from Rachel Carson's Silent Spring (1962).

> *Chemicals sprayed on croplands or forests or gardens lie long in soil, entering into living organisms, passing from one to another in a chain of poisoning and death. Or they pass mysteriously by underground streams until they emerge and, through the alchemy of air and sunlight, combine into new forms that kill vegetation, sicken cattle, and work unknown harm on those who drink from once pure wells.*

Mysterious! Alchemy! Unknown harm! Carson was a bona fide scientist, not one to see things as unexplainable. She most certainly didn't believe in alchemy. DDT's proven dangers were a basis of her work. The world's preeminent environmentalist employed the underground river allusion not in ignorance of groundwater science, but to speak of our broader senses.

When we use the term "underground river," we, too, are speaking to our senses. By objective measures, the dimensions of the flow path being one, velocity being another, it's not really a river.

But as with most of nature, there may be exceptions.

CHAPTER 39
KARSTOLOGY

Quid magis est saxo durum, quid mollius unda?
Dura tamen molli saxa cavantur aqua.

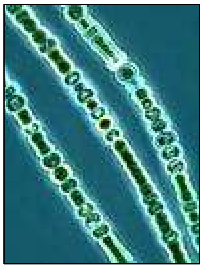
What could be harder than stone, or softer than water?
Nevertheless, water will hollow every stone.

Ovid's Art of Love

Karst Chemistry

"Karst" stems from the Serbo-Croatian “krs” and the Slovenian “kras,” meaning stony bare ground. Karst is the geographic name of the plateau between today's Italy and Slovenia, a landscape typified by an abundance of limestone. We'll take a closer look at this area in Chapter 72, Underground and Balkanized.

Here we'll deal with "karst" in its encompassing sense, the geo-chemical process associated with limestone landscapes. Karstology, the study of karst, must not be confused with the Koreshenity of Chapter 14, Hollow Earth Geophysics. Karstology is bona fide science.



A series of chemical reactions explains why underground caverns are common in karst terrain. Limestone (primarily calcium carbonate) is derived from bicarbonate seashells, coral and detritus deposited on the sea bed. Using carbon dioxide from the ocean water, photosynthetic cyanobacteria of 500 million years past initiated the calcium carbonate precipitation.

$Ca^{++} + HCO_3^{-} + CO_2 \rightarrow H_2O + O_2 + CaCO_3\downarrow$

With subsequent tectonic uplift or sea-level fall, the limestone becomes a terrestrial stratum.

Rainwater absorbs carbon dioxide from the atmosphere to form weak carbonic acid.

$H_2O + CO_2 \rightarrow H_2CO_3$

As the carbon dioxide concentration between soil particles can be 300 times higher than that in the air above, infiltration through topsoil further drives acidification. By chemical definition it's still a "weak" acid and we'd not deem it acidic to taste, but a chemical agent needn't be concentrated if given millions of years to do its job.

The carbonic acid joins with the calcium carbonate to form calcium bicarbonate.

$H_2CO_3 + 2CaCO_3 \rightarrow 2Ca(HCO_3)_2$

The calcium bicarbonate dissociates into its highly-soluble ionic components, a calcium cation and two bicarbonate anions.

$Ca(HCO_3)_2 \rightarrow Ca^{++} + 2HCO_3^{-}$

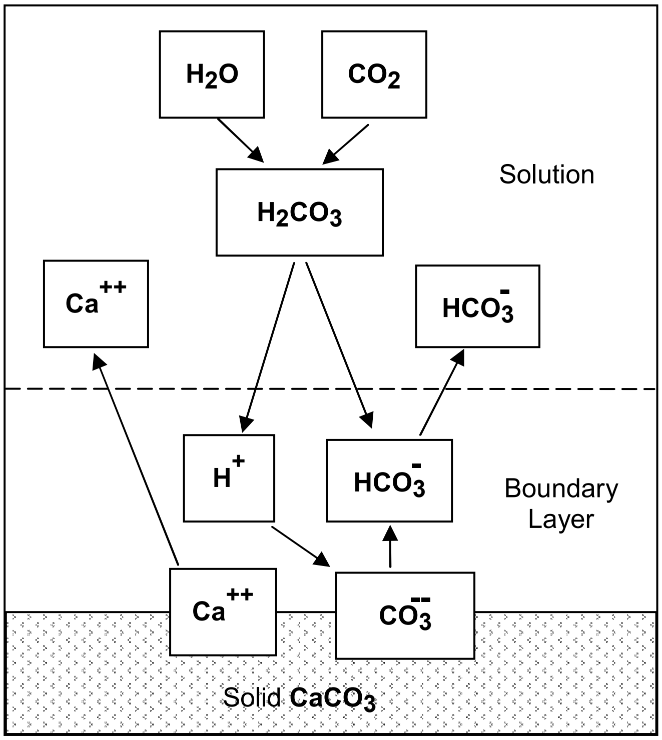
The ions flow onward with the groundwater until reaching an environment where carbon dioxide is present, causing calcium carbonate to re-precipitate as stalagmites, stalactites or caliche.

$$Ca^{++} + HCO_3^{-} + CO_2 \rightarrow H_2O + O_2 + CaCO_3\downarrow$$

Most of the cations, however, ultimately reach the sea to again nourish cyanobacteria, thus closing the cycle.

STALACTITE
STALAGMITE

For those less inclined toward chemsitry equations, we can reduce the geochemistry to a diagram.

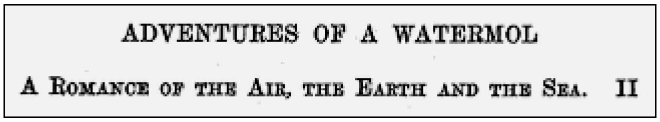


The photo is from Krizna, Slovenia, the two explorers colorized to give perspective. The shallow water on the cave floor is the vehicle of arriving carbonic acid, departing calcium bicarbonate and ultimately-reconstituted calcium carbonate. Flow velocity in this cave is in the order of 0.5 meters/minute, a veritable geological calcium racetrack.

We'll paddle a deeper reach of the same cave in Chapter 72, Underground and Balkanized.

About ten percent of the earth's carbon dioxide is absorbed in limestone, making the karst process, like mangrove swamps and rainforests, an agent of atmospheric buffering.

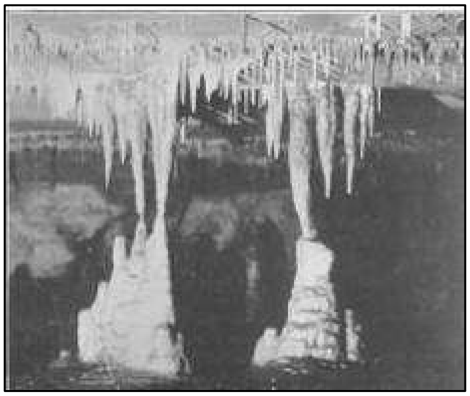
We'll insert a portion of a February 1917 Scientific Monthly article by H.L. Fairchild in which a chatty water molecule, having told of experiences in the atmosphere, now speaks of his subterranean sojourn.



ADVENTURES OF A WATERMOL

A ROMANCE OF THE AIR, THE EARTH AND THE SEA. II

> *All the underground river channel and the cave had been the work of other watermols, my predecessors, for thousands of years. But not only had they dissolved and removed the rock to make the cave, but to show that they could build as well as tear down they had formed beautiful objects in the cave as samples of their construction.*



"Watermol Architecture"

> *Long masses of translucent limestone, of white, yellow and pink color, and shaped like icicles, were left hanging from the roof of the cave-stalactites. In some parts of the cave, which the lake did not cover, conical, needle-shaped and columnar masses of the same elegant material rose from the floor-stalagmites.*
>
> *Very slowly the drift carried me through the lake and finally out of the subterranean channel into the open air and light.*

Less common than dissolution by acidic rainwater, but potentially more dramatic, is karstification by sulfuric acid, New Mexico's Carlsbad Caverns (Chapter 26) being an example.

Oxygenated surface water seeps into a terranean substrata containing petro-carbons where it oxidizes hydrogen sulfide to form sulfuric acid.

$$2O_2 + H_2S \rightarrow H_2SO_4$$

The sulfuric acid migrates upward into calcium carbonate to form carbonic acid and calcium sulfate.

$$H_2SO_4 + CaCO_3 \rightarrow H_2CO_3 + CaSO_4$$

The calcium sulfate hydrates into gypsum.

$$CaSO_4 + 2H_2O \rightarrow CaSO_4 \cdot 2H_2O$$

The acidic upflow causes the cave to form from the bottom up, the opposite of rainwater karstification. Degradation accelerates as the cracks widen, causing rapid cavern enlargement and probable eventual collapse of the entire cave structure.

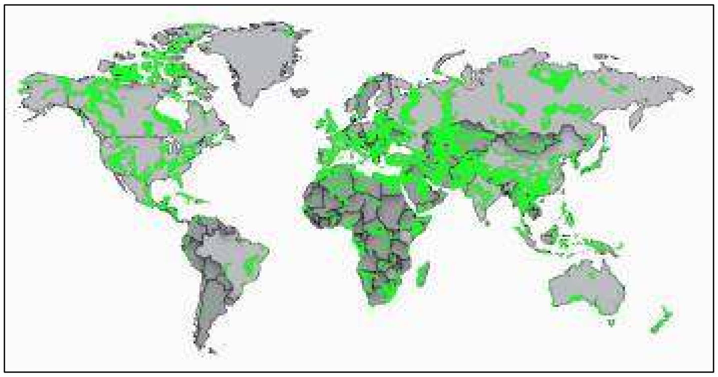
Another less-common karst phenomenon involves the granular transport of calcite, a relatively stable polymorph of calcium carbonate.

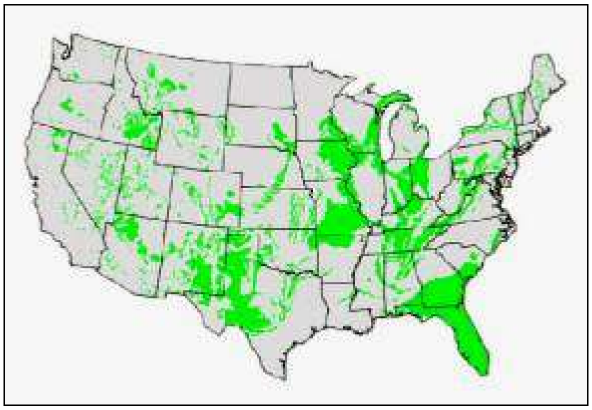
Snowy River in New Mexico, thought to be the world's largest continuous calcite formation, recently began to flow after 150 dry years. The passage is 3 kilometers in length.

Geographic Occurrence

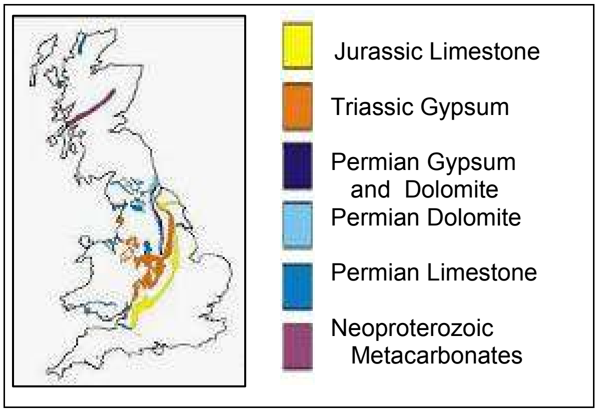
Karst landscapes occupy approximately one-sixth of the earth's land surface and are home to one quarter of the world's population.

The US Geological Survey estimates that roughly 40 percent of the groundwater used for drinking in the United States comes from karst aquifers





United States Karst Regions



British Karst Regions

Swiss Cheese, It's Not

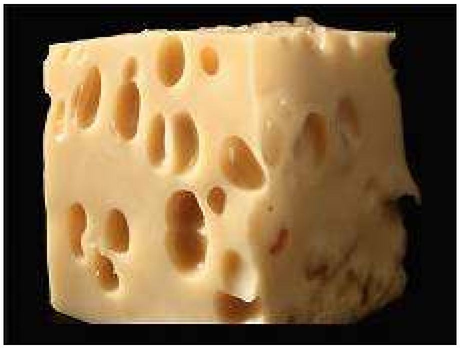
Let us begin with a flawed description of karst structure, but one we might enjoy investigating in person.

The Jura plateau -- the source of the geologic era "Jurassic" -- on the Franco-Swiss border is almost entirely limestone. The source of the River Loue draws under the mountains from the River Doubs, the connection discovered in 1901 when a spill from the Pernod distillery appeared on the other side.

Elisee Reclus describes the terrain in The Earth: A Descriptive History of the Phenomena of the Life of the Globe (1871).

> *Many mountains are penetrated in every direction with caverns and passages, just as if the whole rocky mass was nothing more than an accumulation of cells.*

Reclus' "an accumulation of cells" brings to mind the structure of Swiss cheese.



Swiss Cheese

Franco-Swiss Karst

Have we thus a picnic of Swiss cheese, an Alpine landscape and a French liqueur?

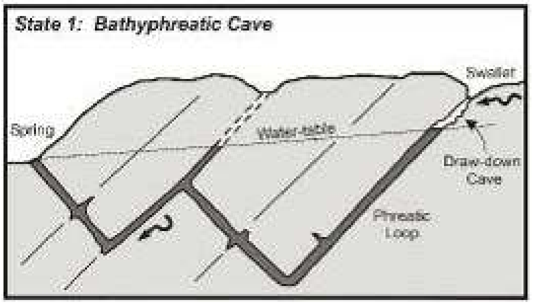
Unfortunately not.

Younger karst formations tend to transmit discharge through ubiquitous micro-structure, but as such porosity clogs with time, flow concentrates in the larger, less-impeded, channels. Unlike Swiss cheese, the karst process is one of continuous pathways, not individuated cells.

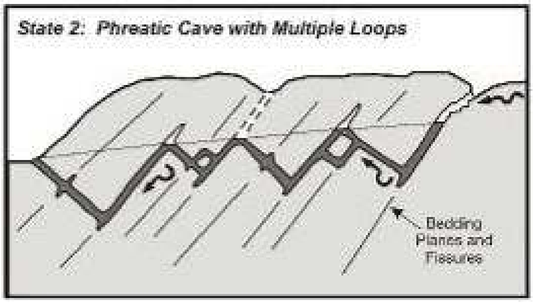
The Water Table

Limestone dissolution occurs at or near the water table, the boundary between the atmospheric gasses and saturated media. If the water table rises, the zone of karstification elevates accordingly, leaving below a saturated, but oxygen-deprived stratum, but unlike sugar cube that will keep liquefying at the bottom of a coffee cup, limestone that's no longer dissolving.

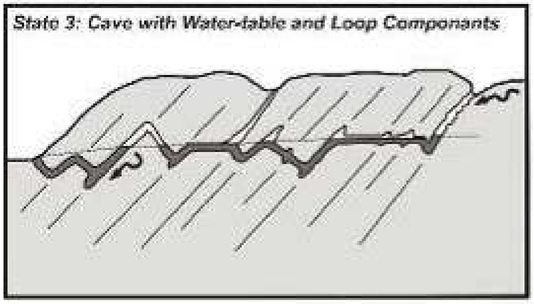
The cross-sections below illustrate differences in cave formation in relation to the water table.


State 1: Bathyphreatic Cave
Swallet
Spring
Water-table
Draw-down Cave
Phreatic Loop

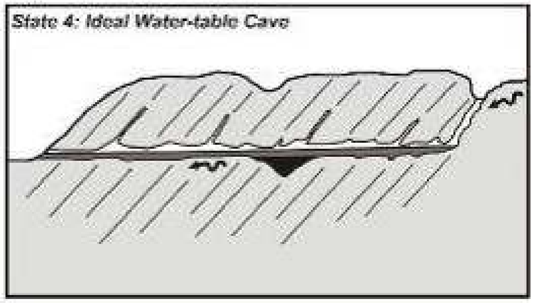
Where fractures are widely spaced, cave systems follow deep flow paths because no shallower routes are open.


State 2: Phreatic Cave with Multiple Loops
Bedding Planes and Fissures

When the frequency of penetrable fractures is higher, caves with deep phreatic loops develop, separated by short vadose stretches.


State 3: Cave with Water-table and Loop Componants

Caves with a mixture of shorter, shallower loops and quasi-horizontal passages develop at or near the water-table

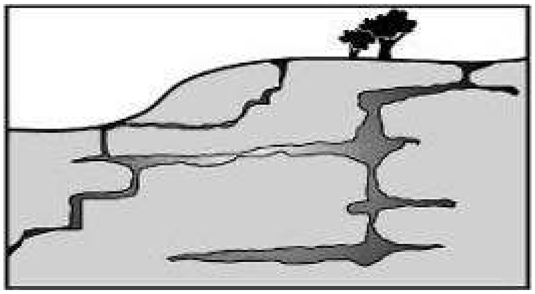

State 4: Ideal Water-table Cave

Where fractures are aligned in the direction of regional flow, direct routes to a spring can develop at or close to the water-table.

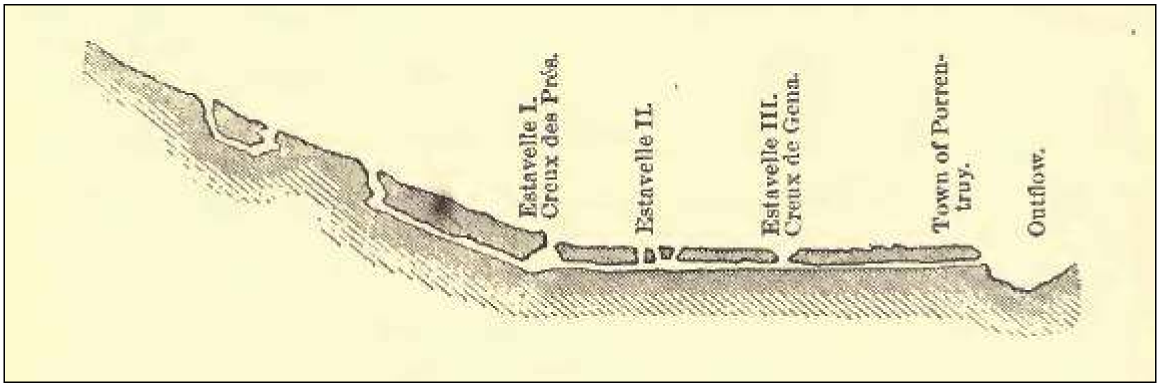
"Phreatic loops" are formed where water descends down-dip along a bedding plane and then must rise up a joint or fault to regain a higher bedding plane. The more joints and bedding planes, or the longer they are, the more likely a cave will develop at or close to the water table.

The horizontal path is not random, however, but follows the path of least hydraulic resistance, a route that typically follows vertical fault lines to the lateral plains of sedimentary bedding.

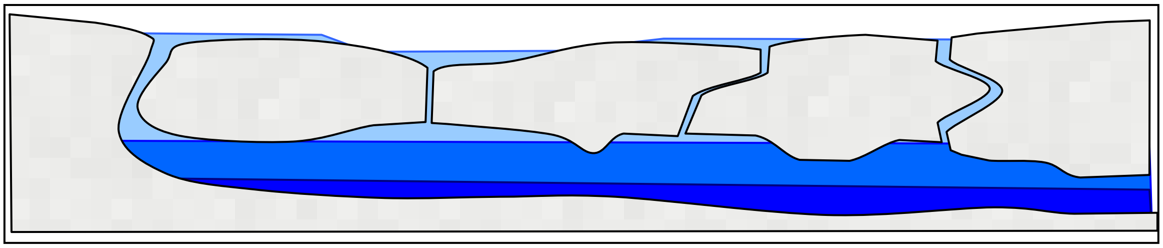
Karst conduits tend to be steeper than their surface counterparts because until they reach the water table, fissures can keep dissolving their way downward.



An "estavelle" is an orifice which, depending on weather and season, can serve either as a sink or as a source of surface water. "Estavelles of Porrentruy" is from Reclus reference.

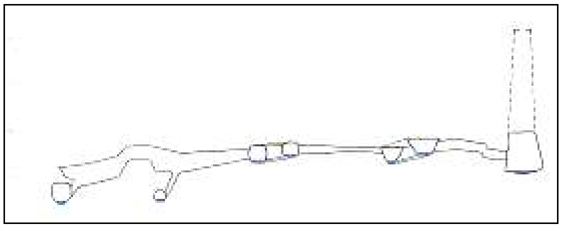


Karst systems can flood rapidly. When caverns are filled and the remaining storage capacity is only what remains in downstream shafts, those perforations may flow upward.

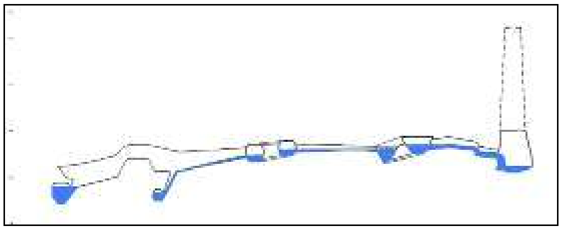


The dark blue shows the dry-season "underground river" flowing to the right. Medium blue represents the condition when the caverns are mostly filled, the flow yet downward in all columns. The light blue illustrates reversed flow direction in the second column.

J.F. Quinlan, R.O Ewers and T. Aley, Practical Karst Hydrology (1991), National Ground Water Association, provide a set of water surface elevations from Kentucky's Parker Cave System.



Base flow conditions



Immediately after heavy rain

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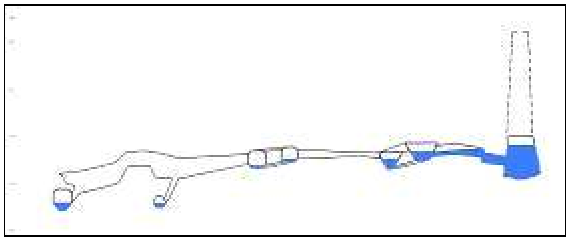
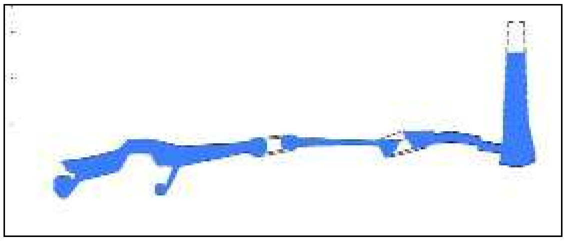
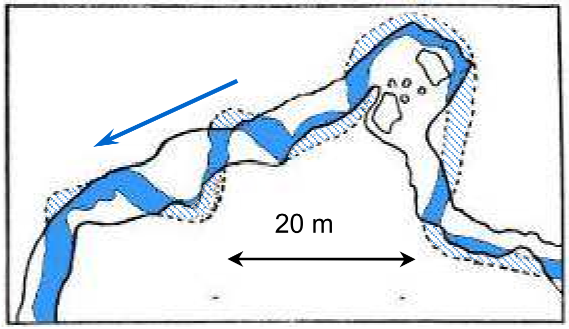


One day after same rain



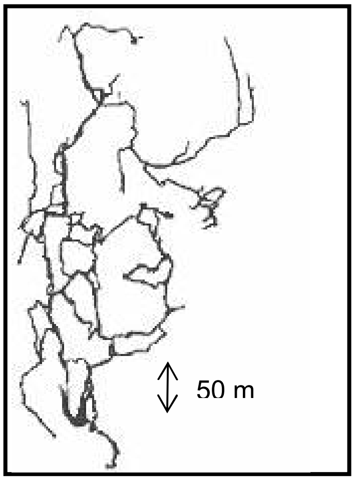
After several heavy rains

Planform



Stream meanders, above or below ground, are a geomorphic adjustment of watercourse slope in pursuit of dynamically-equilibrated energy dissipation

Channels incised in karst floors can likewise meander, as seen in the Cave of the Mounds, Wisconsin, the figure adapted from "Vadose and Phreatic Features of Limestone Caverns," Journal of Geology, August 1942, by J. Harlen Bretz.



In plan view, subsurface karst drainage exhibits a blocky structure, not the leaf-like dendritic pattern more common to above-ground drainage networks. Peacock Springs Cave in Suwanee County, Florida serves as an example of flow paths directed by geologic bedding, not by the geologically more-recent evolution of surface topography.

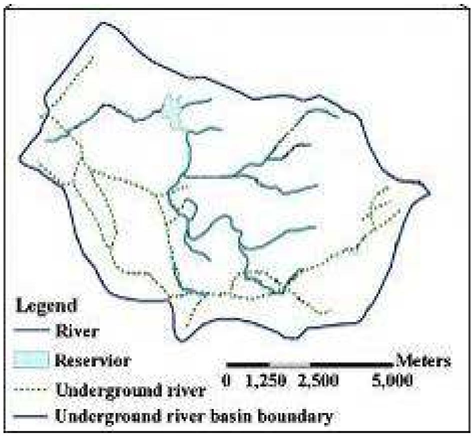
Unlike a uniformly-porous aquifer -- the subject of the last chapter -- in which flow enjoys a broad spread of flow paths, only a minute fraction of a limestone cross-section is in conduit form.

We will touch on the topic of water dowsing in Chapter 46, but the figure illustrates the dowser's challenge. A well drilled into a black line hits a passageway which may or may not currently contain water. A well that misses may be dry.

"The Mystery of the Far-Famed Indian River Which Loses Itself," Saint Paul Globe, July 25, 1902, notes separated subterranean streams.

> *Another peculiar feature connected with the gulf* [a location along Indiana's Lost River, which as we noted in Chapter 20, More Boys Club Serials, is just one of several rivers by that name] *is the two streams that burst from a ledge of rock at one side. After a rain one stream, will always run muddy water, while the other will remain perfectly clear. This has never been accounted for, being put down as one of the mysteries and freaks of Lost River.*

Karst watercourses are in fact often interlaced by multiple connections, but in 1902, when the evidence of an underfoot channel was but a sinkhole and a spring, it was common to assume a pipe-like communication.



As does runoff on the surface, subsurface channels form branching networks. Watershed boundaries, however, above and below, are not always the same.

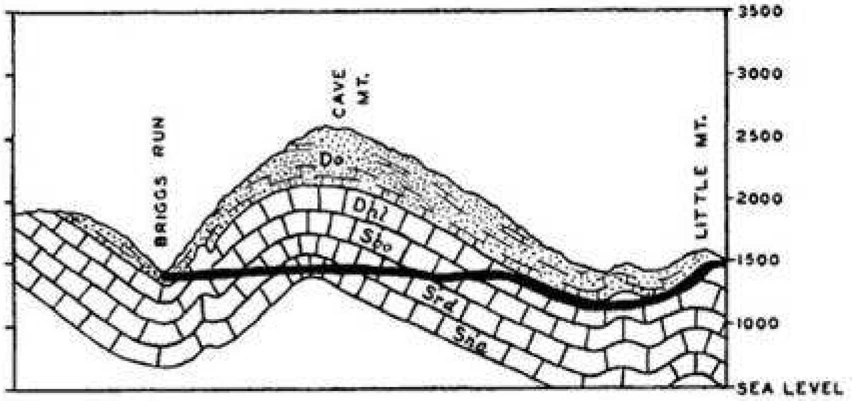
"The Hydrologic Function and Behavior of the Houzhai Underground River Basin, Guizhou Province, Southwestern China" by Lihong Liu, Longcang Shu , Xunhong Chen and Thomas Oromo, Hydrogeology Journal, September 16, 2009, illustrates an underground river basin.

Piracy

"Subterranean Stream Piracy in the Ozarks" by C.L. Dake and Josiah Bridge brings to mind swash-buckled moonshiners, but the Bulletin, Technical Series 7:1, School of Mines and Metallurgy, University of Missouri, 1924, is not as folkloric.

Surface water that seeps into cracks in channel bedrock can lead to chemical exfoliation and freeze expansion, enlarging the crack, which in turn allows more water into the crack and accelerates erosion. When cracks combine to create an alternate subsurface pathway to a nearby stream, subterranean stream piracy occurs. The pathway may enlarge until most, if not all the water flows through it, rather than the original route.

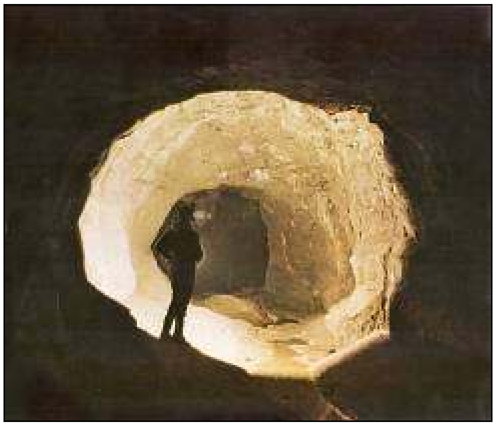
A stream piracy reference, Solution and Stream Piracy (1939) by H.M. Fridley, is based on the 3-kilometer subterranean piracy of the South Branch Potomac in West Virginia.



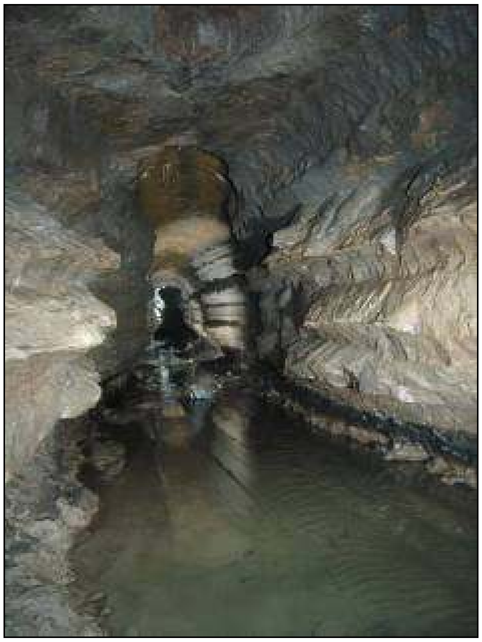
We will have more to say on the subject of subterranean stream piracy in Chapter 81 where it has to do with scoundrels and cutthroats who operated in New York Harbor.

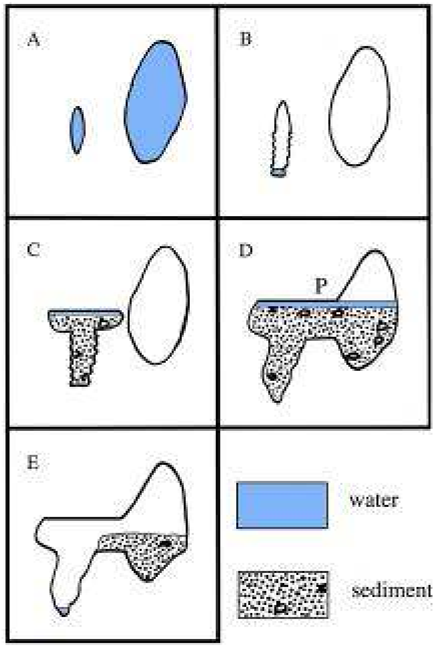
Conduit-Section

A "phreatic cave" formed by a completely filled cross-section can be identified by its circular shape. Nature prefers circles, a concept we chronicled in Chapter 7.



Most karst conduits aren't cylindrical for long, however. The photo below from Spring Valley Cave, Minnesota, illustrates progressive down-cutting. The diagrams show the process of paragenesis, the terminal stage being a flat-bottomed floor of sedimentary material.

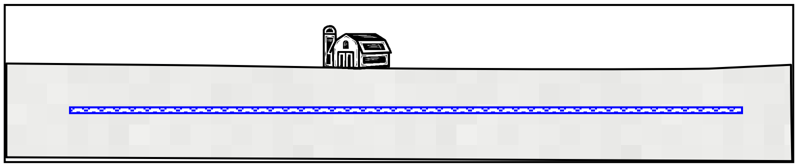




Not all that's reported about cave geometrics, however, should be believed, as evidenced by "A Mysterious Underground River," New York Times, April 23, 1893.

> *Charlotte, N.C., April 22. -- An oil and fertilizer mill is being erected in the suburbs of this city, and Mr. Knox, the engineer, in prospecting for water struck a great underground stream strongly impregnated with iron. Other wells were driven down, and it was discovered that the stream is 700 feet wide and 6 feet deep. This underground river is 45 feet from the surface.*
>
> *This immense volume of water has caused considerable excitement, and its iron taste precludes the idea that it is a part of the Catawba River, which is free from stone. Where it comes from and where it goes is a mystery.*

The scale diagram below shows the stream's cross-section.

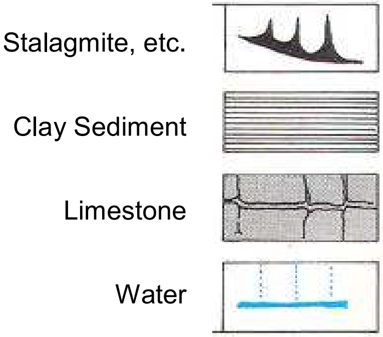


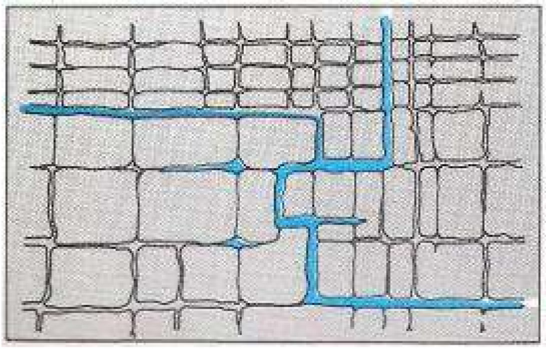
For geotechnical reasons, the thickness of a stable karst roof must exceed roughly half of the cave width. The reported ceiling would likely have collapsed long ago.

Collapse

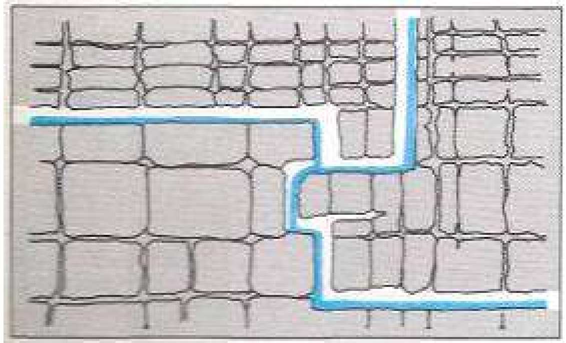
We'll look at one dramatic consequence of karst collapse in the chapter to follow, Sinkholes, but here we'll introduce the topic in the framework of the larger karst process.

The drawings below, adapted from Caves (1974) by Tony Waltham, illustrate the general sequence of cave formation.

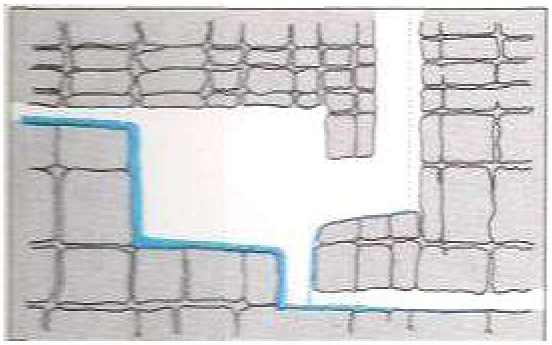




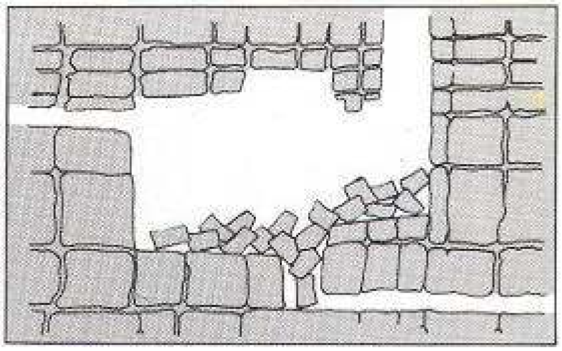
1. Water in fissures -- moving slowly



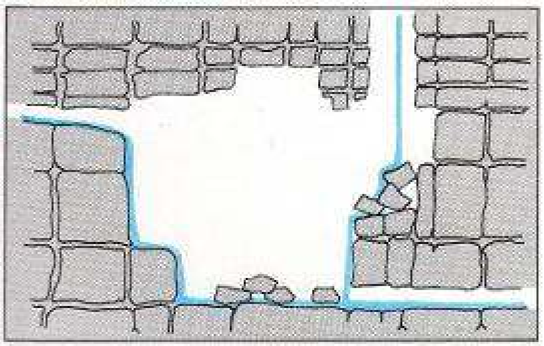
2. Stream caves are established



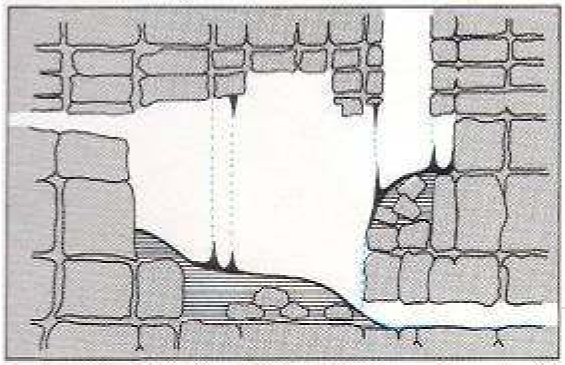
3. Stream erosion cuts out chamber



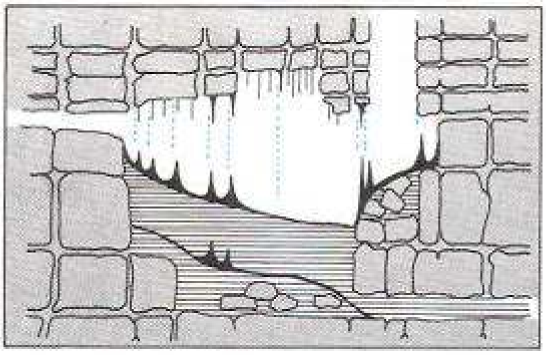
4. Partial collapse of roof



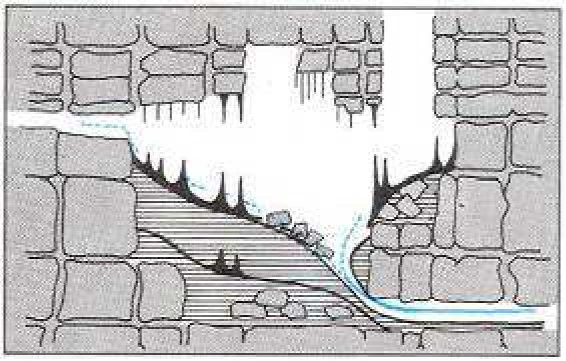
5. Solution of collapse debris and floor



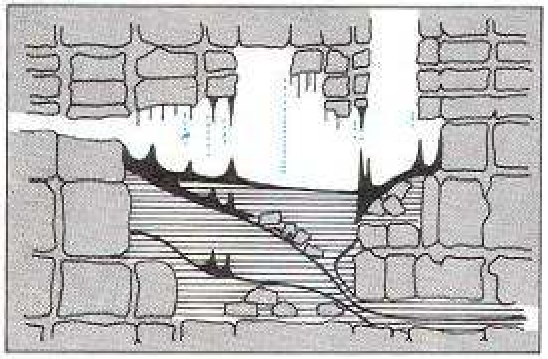
6. Deposition of clay sediments followed by stalagmites



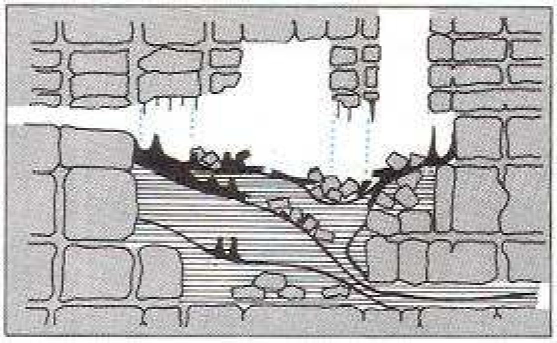
7. Deposition of second phase of clay sediment followed by more stalagmites



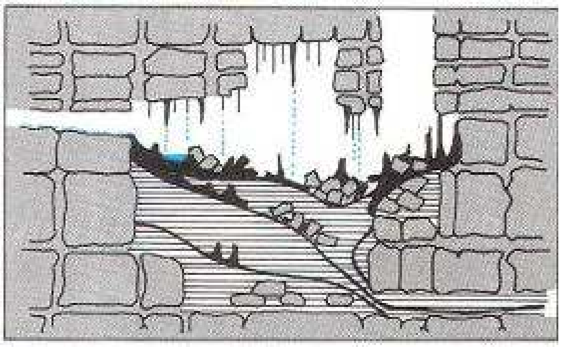
8. Erosion of some of the clay sediments and stalagmite and further collapse



9. Deposition of a third phase of clay sediment and stalagmites



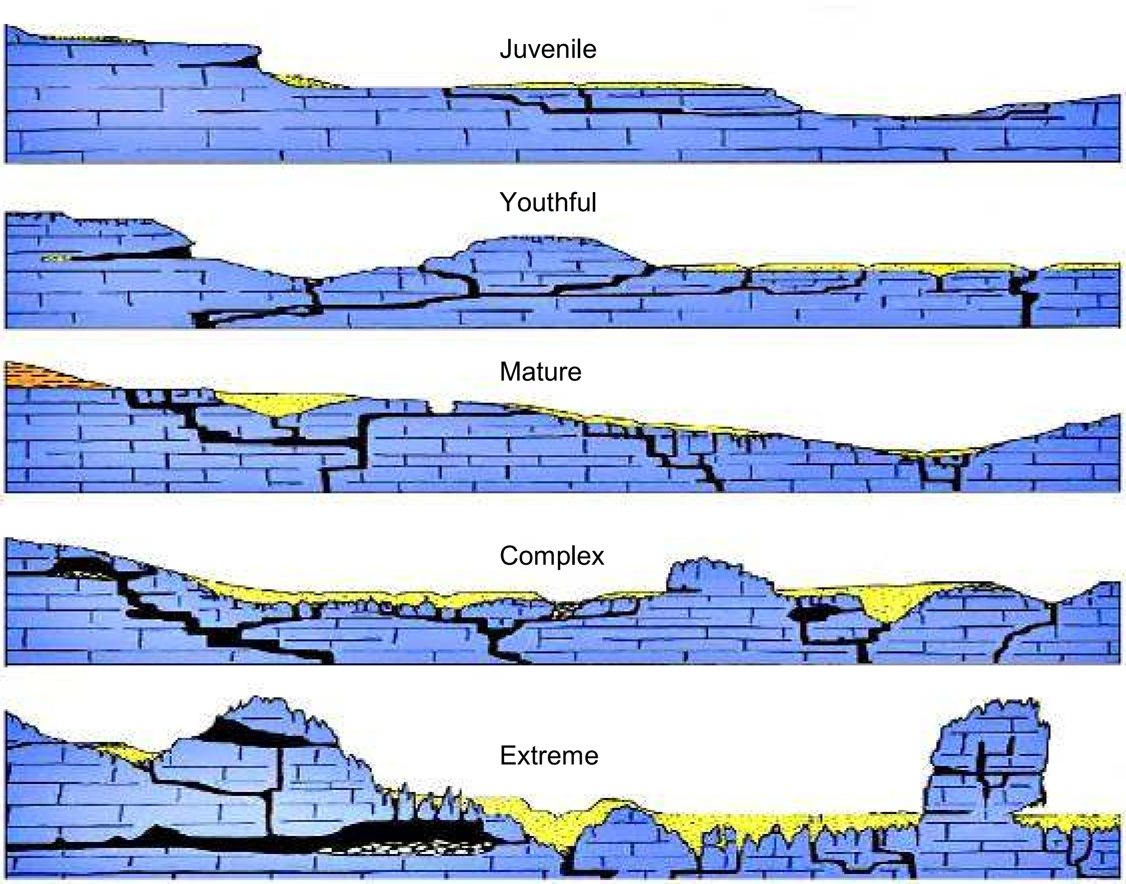
10. Settling of clay sediments, some collapse of stalagmites and further roof collapse



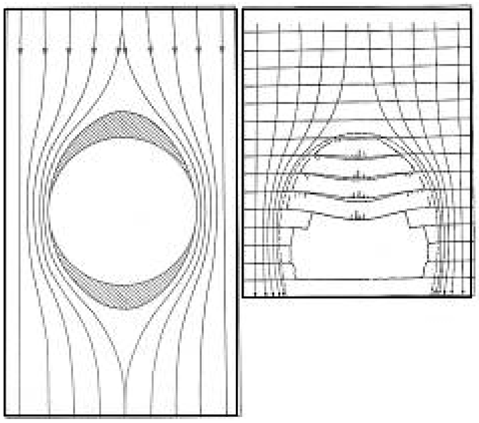
11. Modern phase of calcite deposition

The sequence is measured in geological time, typically 10,000 to 100,000 years to reach traversable size.

Another rendition of karst stages, this time in elevation, as opposed to cross-section.



It may not be the water, per se, but its withdrawal that initiates catastrophic change in conduit cross-section. The figure illustrates stress lines around natural cavities in limestone.



Left: Distribution around water-filled void below water table

Right: Distribution around air-filled void after lowering water table.

Natural Bridges and Tunnels

Natural bridges begin as subterranean conduits, but subsequent collapse has left only a remnant of the original roof.

NATURAL BRIDGE VA.

The Lost River at Natural Bridge, Virginia.
LOST RIVER

> *"Men have risked their lives trying to locate the meanderings of this stream, but have been unsuccessful."*

Virginia's Natural Bridge, 65 meters above today's creek bed.

George Washington is said to have surveyed Natural Bridge, though he made no mention it in his journals. More certain is that Thomas Jefferson purchased "the most sublime of nature's works," in his words, from King George III.

Herman Melville alluded to the formation in describing Moby Dick,

> *But soon the fore part of him slowly rose from the water; for an instant his whole marbleized body formed a high arch, like Virginia's Natural Bridge.*

As we noted in chapters dealing with literary fiction, whaling ships have inexplicable propensity to encounter underground seas.

And while we're visiting Natural Bridge, here's a children's version, "The River that was Found and Lost," St. Nicholas (1911) by Mary Mapes Dodge.

> *It all depends on how you look at it. Some name it "The River that was Found"; others, "The River that was Lost"; but I observe that all visitors refer to it by one or the other of the two names, mostly as "lost," probably because that is the name on the sign that directs the visitor to follow the path through the ravine, for about a quarter of a mile, north of the Natural Bridge of Virginia.*
>
> *Out of a cavern the little "river" gurgles and bubbles, sometimes even with a tinkling sound. It flows clear and cool for a few feet, and then vanishes under the ledge. There is no other trace of the stream in all the surrounding territory. It has no sphinx-like silence as one propounds questions as to its origin and its purpose, but seems almost to laugh, "I'll never tell," when it is asked, "Whence are you coming and whither are you going?"*

Natural Tunnel in western Virginia, 260 meters long, up to 60 meters wide and 24 meters in height, was carved through a limestone ridge by Stock Creek. The railroad constructed through the tunnel in 1893 still operates, but only to transport coal. When the tracks are clear, Natural Tunnel State Park offers walking tours.

William Jennings Bryan called Natural Tunnel the “Eighth Wonder of the World,” a title, we may recall from Chapter 38, also awarded to Old Jumbo well of Iowa,

Sunbright Hwy
1600'
1600'

Natural
Tunnel
$5.00

Wonder of the World

The Eighth

RailPictures.Net - Image Copyright © Ron Flanary

Natural Tunnel was a subject of Outlines of the Earth's History, A Popular Study in Physiography (1898) by Nathaniel S. Shaler.

> *All the while that subterranean streams are cutting the caverns downward, the open-air rivers into which they discharge are deepening their beds, and thereby preparing for the construction of yet lower stories of caves. These open-air streams commonly flow in steep-sided, narrow valleys, which themselves were caves until the galleries became so wide that they could no longer support the roof. Thus we often find that for a certain distance the roof over a large stream has fallen in, so that the water flows in the open air. Then it will plunge under an arch and course, it may be, for some miles, before it again arrives at a place where the roof has disappeared, or perhaps attains a field occupied by rocks of another character, in which caverns were not formed. At places these old river caverns are abandoned by the streams, which find other courses. They form natural tunnels, which are not infrequently of considerable length. One such in southwestern Virginia has been made useful for a railway passing from one valley to another, thus sparing the expense of a costly excavation.*

Pop Quiz

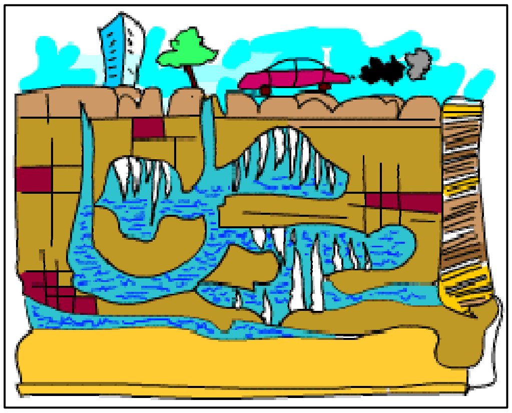
Let us test our knowledge of karstology.

Q: What can we deduce about the geologic history of the cross-section shown to the right?

A: As stalactites and stalagmites don't form under water, this cavern subsequently flooded.

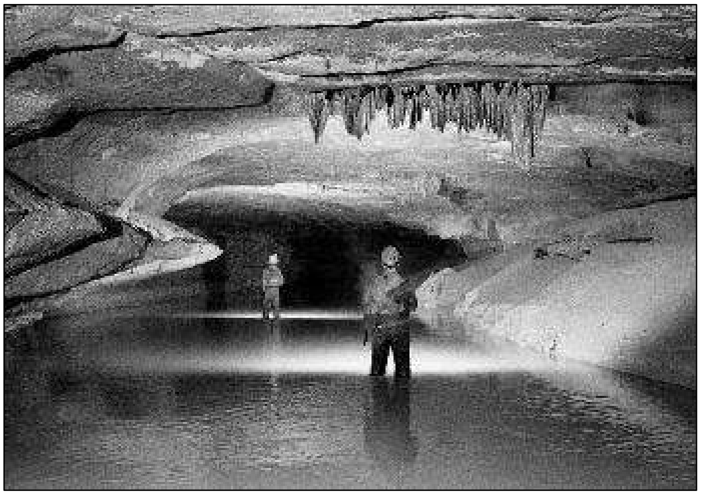
Q: And what about the future?

A: Chapter 75, Mainlining the Sewage, suggests an unfortunate consequence of an oil leak from the red car.



Q: Stalagmites or Stalactites in Indiana's Lost River?

A: Stalactites.

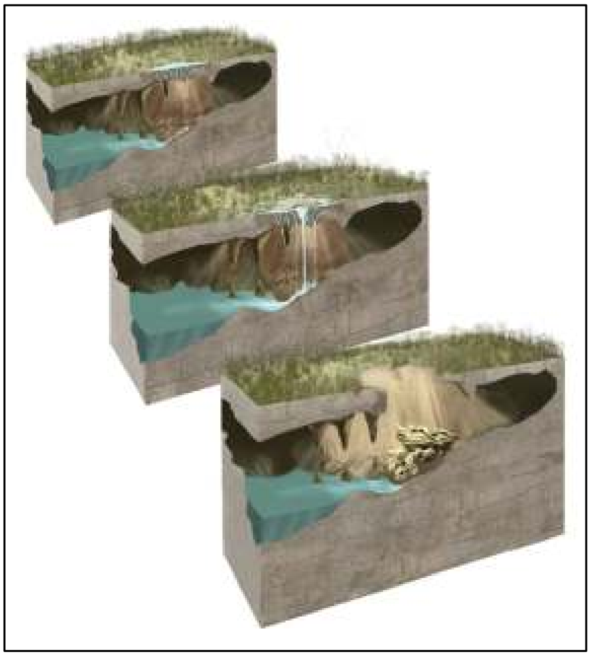


CHAPTER 40
SINKHOLES

Sinkholes are natural depressions in the land surface caused by the ceiling collapse of karst cavities not far below the surface.

Sinkholes may range in both diameter and depth from a few to several hundred meters, may vary in form from bowl-shaped to precipitous chasms and may be created gradually or catastrophically.

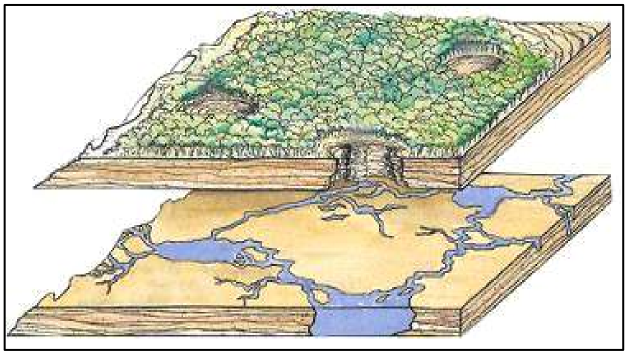
Our interst in sinkholes derives from the fact that sinkholes are almost aways associated with subterranean streams. A subterranean cavern of sinkhole magnitude is the product of water pass-through at a rate sufficient to bear away vast quantities of solute. A stagnent aquifer leaves no caves.



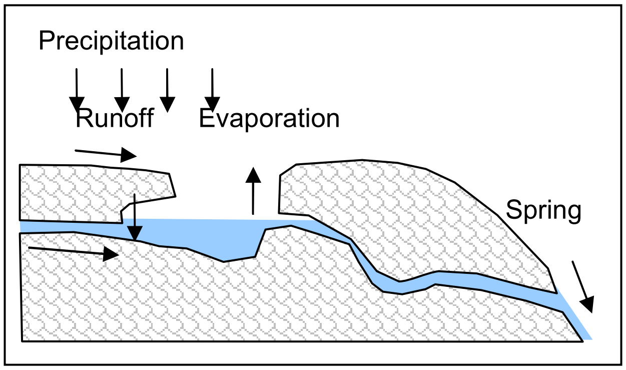
It is not uncommon for inflow and outflow conduits to be recognizable immediately after sinkhole collapse, but once the sinkhole attracts local runoff, washed-in soil tends to obscure the hydrologic features. Degraded limestone covered by only a thin horizon of soil can lead to a saucer-shaped depression that develops continuously, but slowly.

If the limestone is replaced by cascading particulates too stable to be washed onward, a sinkhole may remain only a few meters in dimension.

Whatever the surficial appearance of a sinkhole, however, there is reasonable certainty of active karst channels below



Typical hydrologic pathways



Journalistic Pursuit

As our subterranean journey is as much a passage though social history as it is one of science, we'll note how sinkholes have been described in popular journalism. While the Roman encyclopedists (Chapter 3) were geographically aware of karst, theirs wasn't a scientific curiosity. By the 18th century, however, the emerging natural sciences had become parlor talk in lettered class.

In The Natural History of Lancashire, Cheshire, and the Peak in Derbyshire (1700), Charles Leigh noticed that in Derbyshire,

> *Several cavities, which the Inhabitants call Swallows,* [and] *into these run several Rivulets of Water, but where the water has its Exit is not known... It is from them these Subterraneous Rivers are formed.*

Derbyshire landscape

From "Observation on the White Limestone and other Eocene or Older Tertiary Formations of Virginia, South Carolina, and Georgia," Quarterly Journal of the Geologic Society, 1845,

> *One of the characteristic features of the region of tertiary white marl and limestone in South Carolina and Georgia, is the frequent occurrence of lime-sinks, or funnel-shaped cavities, arising from natural tunnels in the subjacent limestone, through some of which subterranean rivers flow. At Wantoot, there is one of these sinks in the limestone, and a spring issues from the rock so much above the temperature of the air during a frost as to send off clouds of steam.*

South Carolina's Santee Cooper Hydroelectric and Navigation Project's Lake Moultrie submerged the Watoot Plantation in the early 1940s.

From The Encyclopedia Britannica, A Dictionary of Arts, Sciences and General Literature (1890),

> *Another remarkable feature of Florida are the subterranean streams which undermine the rotten limestone formation, creating numerous cavities in the ground called "sinks." These are inverted conical hollows, or tunnels, varying in extent from a few yards to several acres, at the bottom of which running water often appears.*
>
> *A most remarkable spring, situated 12 miles from Tallahassee, has been sounded with 250 fathoms of line before finding bottom. The outflow forms a beautiful lake, transparent and cold as ice even in the hottest weather. The great sink of Alachua County is a subterranean passage by which the waters of the Alachua savanna are supposed to discharge themselves into Orange Lake. In fact, the geological structure of the State is remarkable, much of its surface seeming a crust through the openings of which underground lakes and rivers force their way.*

The 250-fathom (460-meter) depth is likely exaggerated, but numbers aside, we can picture the awe.

In Outlines of the Earth's History, A Popular Study in Physiography (1898), Nathaniel S. Shaler advises the novice explorer to expect a bottle-shaped shaft and take the easy way out.

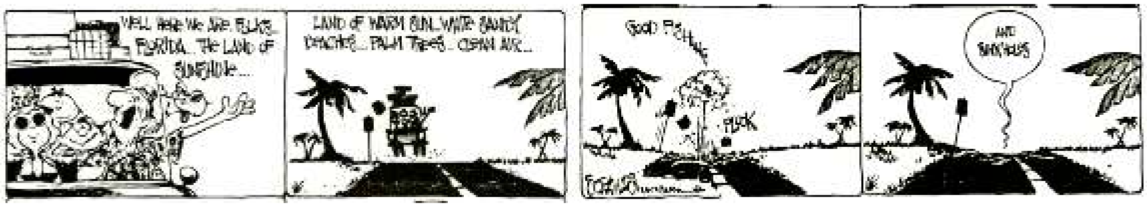
> *When one is lowered away through an open sink hole, though the descent may at first be somewhat tortuous, the explorer soon finds himself swinging freely in the air, it may be at a point some hundred feet above the base of the bottle-shaped shaft or dome into which he has entered. Commonly the neck of the bottle is formed where the water has worked its way through a rather sandy limestone, a rock which was not readily dissolved by the water.*
>
> *The explorer may continue his descent until he attains the base of this vertical section of the cave, where he is likely to find himself delivered in a pool of water of no great depth, the bottom of which is occupied by a quantity of small, hard stones of a flinty nature, which have evidently come from the upper parts of the cavern.*
>
> *From the bottom of the dome a determined inquirer can often make his way along the galleries which lead from that level, though it may be after a journey of miles to the point where he emerges from the cavern on the banks of an open-air river.*

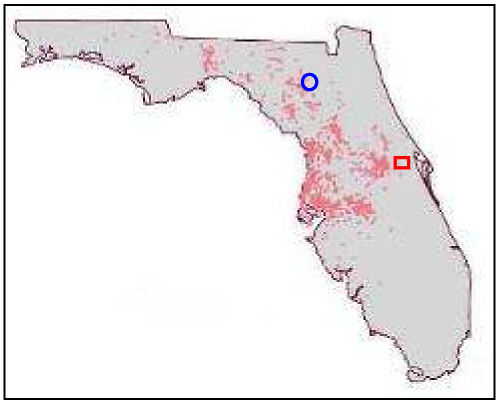
From Cook's Practical Guide to Algiers, Algeria and Tunisia (1904) regarding Biskra, Algeria,

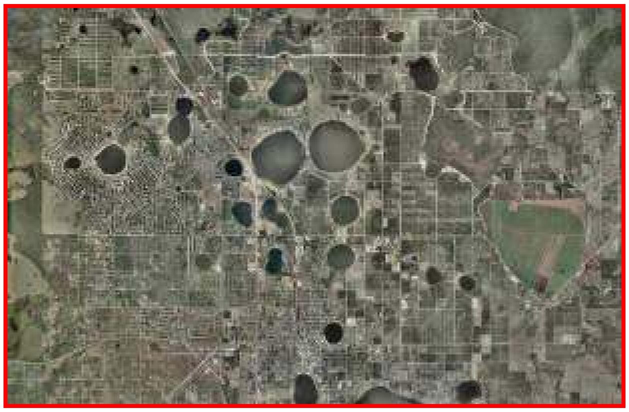
> *In the month of July 1878, after a very stormy day, the soil suddenly gave way, on a surface extending over 30 meters in diameter, causing a tremendous noise, which attracted the attention of the neighboring shepherds. On close examination, a large crevice was discovered creeping downwards, towards the centre of the earth, conducting the explorers to a large mass of water forming a lake of about 50 meters long by 30 wide. On the right side of the cavern a stream, three meters wide, carried with terrific crash an enormous quantity of water to this subterranean lake.*

Florida

The Sunshine State has no scarcity of such features. The Florida Department of Environmental Protection database lists more than 3200 citizen-reported "subsidence incidents."


WELL HERE WE ARE, FOLKS... FLORIDA... THE LAND OF SUNSHINE...
LAND OF WARM SUN... WHITE SANDY BEACHES... PALM TREES... CLEAN AIR...
GOOD FISHING
FLICK
AND SINKHOLES



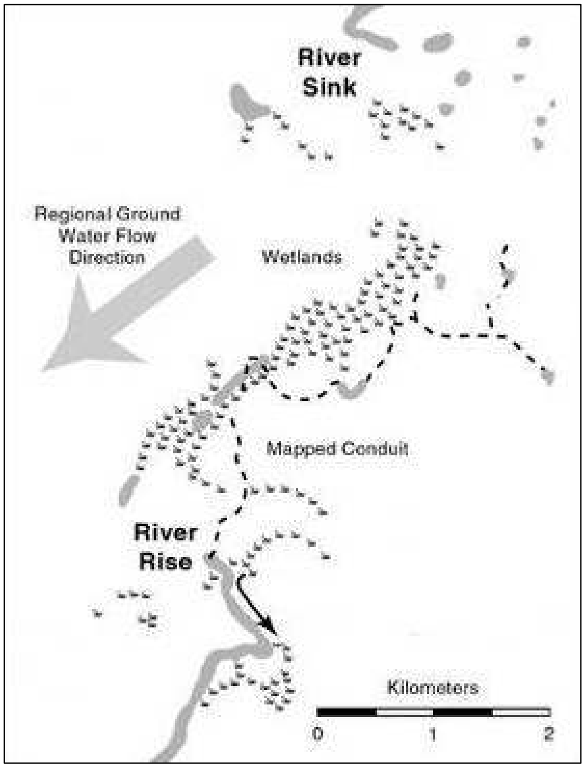


Avon Park, Florida, a community built on the principle of New Urbanism

Florida's Santa Fe River disappears into a sinkhole in O'Leno State Park (blue circle on the map above) and reappears 4.8 kilometers downstream at River Rise Preserve State Park.

Re-emergence

Emergent discharge ranges from less than 1 to more than 100 cubic meters/second. At low flow, only 4 percent of the resurgence derives from the upstream sink; the remainder is from intermediate sources.



For those less bound by the conventional, we've "Florida Sinkholes, Mysterious Actions of the Ground of that State," Daily Northwestern, February 24, 1898,

> *The numerous recent discoveries in some western states, in Central America and in Mexico of the remains of the dwellings of a people who lived beneath the surface of the earth suggest the possibility that these Florida sinks are the breaking-in of the roofs of chambers formed by a race of people who, in the long ago, occupied Florida.*
>
> *A decided similarity exists between many ancient works found in American and Egyptian work. There is no good reason why we should not take what is known of Egypt to at least suggest the form or purpose of the unknown in America. In Egypt and Morocco, I am informed, the excess of grain crops is placed in chambers in the ground, the chamber is closed, and all visible traces of evidence are destroyed.*

> *Might not some of our numerous large sinks represent similar large granaries or store chambers?*
>
> *Several attempts have been made to dig down and see the actual condition -- if there is a chamber and what it contains; if there is a tunnel and what it leads to; but water and quicksand were in every instance too much for the means of the explorer, so it still remains a mystery and no one has yet satisfactorily answered the question: What is a Florida sink?*

An Atlantic prehistory of limestone formation an Atlantis saga of ancient Egyptians? We must keep an open mind.

As tourists and scuba divers, we'll explore other Florida sinkholes in Chapters 52 and 62.

Cenotes, Tiankengs and Poljes

Cenotes, Tiankengs and Poljes -- "sinkhole" in Spanish, Chinese and Slovenian respectively, but each with particular characteristics.

Cenote is the Spanish rendering of the Mayan “d'zonot,” a hole in the ground. We've a few impressions from the early European observers.

As recorded by Diego de Landa, the Roman Catholic priest sent to convert the Maya to Catholicism, in Relacion de Las Cosas de Yucatan (1566),

> *The work of nature in this land with regard to rivers and water sources is very different, while in most of then world the rivers run above the ground, in this land they run through secret passages beneath the earth.*

In 1795, Félix María Calleja, Viceroy of New Spain, wrote,

> *There is a large cave lit by natural skylight; and 200 varas from this cave there is a deep cavity that has a lake with an island.*

From Incidents of Travel in Yucatan (1843) by J.L. Stephens,

> *The cenote was the largest and widest we had seen; in the midst of a thick forest, an immense circular hole, with cragged perpendicular sides, trees growing out of them and overhanging the brink, and still as if the genius of silence reigned within. A hawk was sailing around it... The water was of a greenish hue. A mysterious influence seemed to pervade it, in unison with the historical account that the well of Chichen was a place of pilgrimage and that human victims were thrown in it in sacrifice. In one place on the vary brink, were the remains of a stone structure, probably connected with ancient superstitious rites; perhaps the place from which the victims were thrown into the dark well below.*

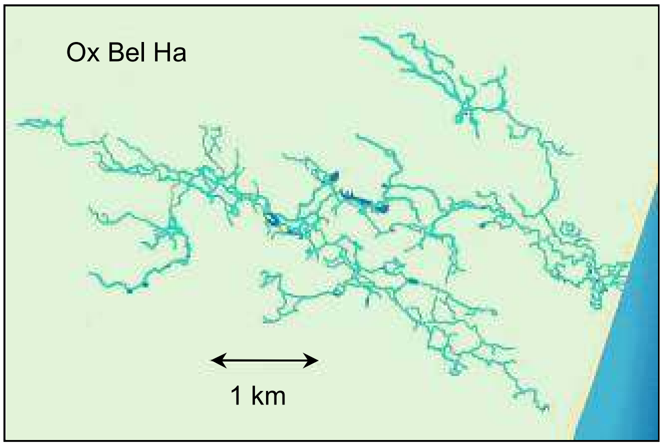
The world’s deepest sinkhole, 329 meters, is the Zacatón in northeastern Mexico. One of a group of five interconnected cenotes, Zacatón is nearly perfectly circular with a diameter of 116 meters.

World Record
Deepest Underwater Cave
329 m

The islands, 3 to 10 meters in diameter, are made from mats of reeds which, in the absence of current, are propelled by the wind. Pliny (Chapter 3) wrote of floating islands in Lake Vadimon covered with rushes and reeds. Athanasius Kircher (Chapter 8) described a group of floating islands known as the "sixteen little boats" floating in Lago della Regina, south of Rome.

Perhaps Marduk's legendary rush mat with dirt heaped upon it (Chapter 1) wasn't so far fetched.

Divers in 2007 were able to connect the dots -- cenote-to-cenote, being more accurate -- navigating the Yucatan's Ox Bel Ha cave system (also know by one of its components, the Sac Actun) via 180 kilometers of passages interconnecting 95 openings, with 3 vents to the Caribbean. As the crow flies, however, the system spans only 10 kilometers.



World Record

Longest Underwater Cave System
180 km

The Great Blue Hole on Lighthouse Reef, Belize, is a sinkhole in origin. There are a number of likewise-named "Blue Holes," some on land, some in the sea. We'll see reference to this one in Chapter 64, Cave Diving, in regard to a fatality.

A terrain of cenotes makes a fine setting of Boys Club fiction. From The Search for the Silver City, a Tale of Adventure in Yucatan (1893) by James Otis,

> *The Indian halted at an opening in the hillside hardly more than large enough for one to go through on his hands and knees, and motioned for the others to enter.*
>
> *Cummings led the way, and while he was doing so Teddy asked Poyor, "Have you been here often before?"*
>
> *"This is the first time."*
>
> *"How could you see a small hole like that while it is so dark?"*

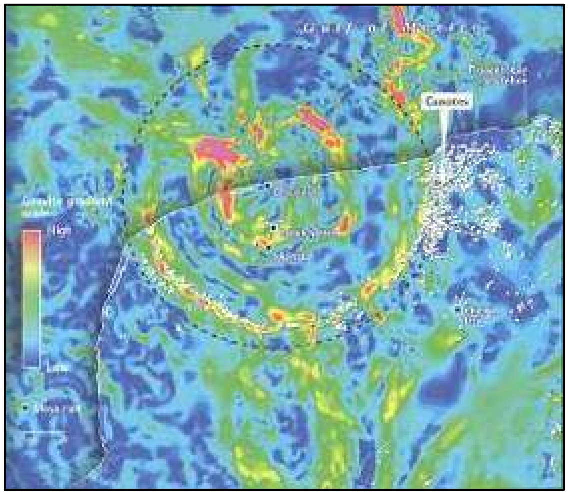
> *"On the line of these caves the earth is always damp. When we halted last I could feel that we were on the underground water course, and it was only necessary to follow it up. Here we shall find both food and drink."*

In 1978, a geophysicist working for the state-owned oil company discovered geophysical anomalies forming a submarine arc 180 kilometers in diameter off the Yucatan Peninsula. This feature, the "Chicxulub Crater," is now thought to be evidence of a 10-kilometer-diameter comet impact 65 million years in the past. Equivalent to 96 teratons of TNT, the collision caused the demise of 70 percent of life on earth, most notably the dinosaurs.

Although cenotes are found elsewhere in the Yucatan, the circular alignment along the crater rim suggests that a groundwater basin formed within the crater, disproportionally dissolving the limestone. Today's sinkholes are thought to have been caused by subsidence of the crater wall.

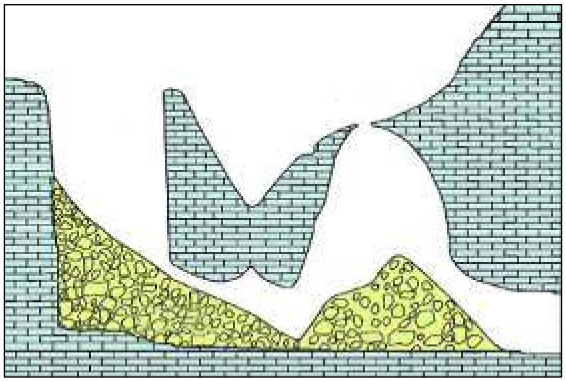
In the gravity anomaly map of the crater area, the white dots indicate cenotes. The lower-left area is the Yucatan Peninsula.

While no one's arguing that the primordial ectoplasm emerged from a subterranean stream, as students of karst hydrology, we endorse the proposition.



A tiankeng -- Chinese for "heavenly pit" -- is a large sinkhole from which the debris mass has been largely removed by a cave river. "Large" is the key; common criteria being,

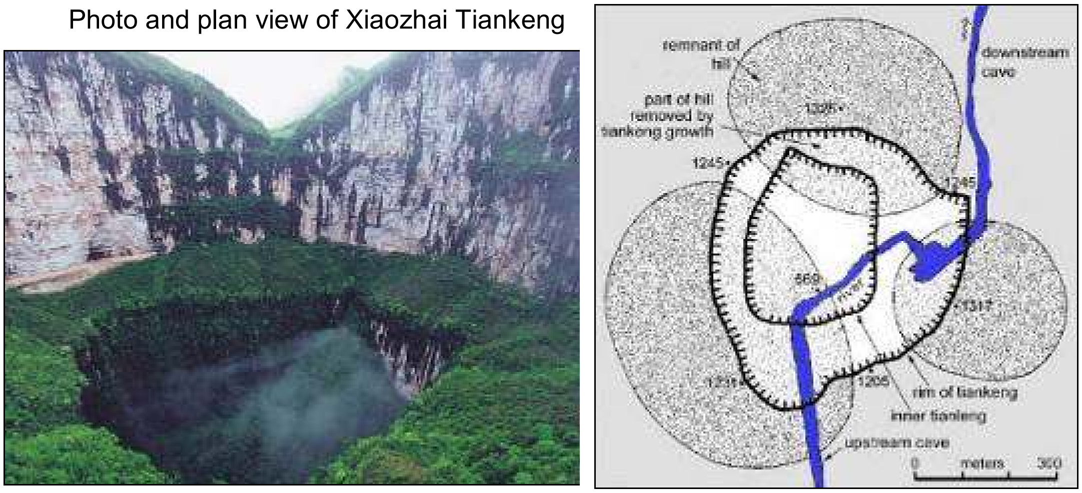
Diameter exceeding 100 meters
Volume greater than 1,000,000 cubic meters
Depth/width ratio between 0.5 and 2
Vertical cliffs around most of the perimeter



Section through 300-meter Biadong Tiankeng and neighboring proto-tiankeng

There are about 75 tiankengs worldwide, two-thirds of which are in China. About half have no visible cave river now flowing through them, but roughly half of these retain associated passages that once bore underground rivers. In some cases, the river now passes unseen below floor debris.

Photo and plan view of Xiaozhai Tiankeng


remnant of hill
part of hill removed by tiankeng growth
1326
1245
1245
downstream cave
569
1317
1291
1208
rim of tiankeng
inner tiankeng
upstream cave
0 meters 300

The 7-kilometer river under Xiaozhai has a mean discharge of 8.8 cubic meters/second. Maximum discharge is nearly 20 times that. Channel slope is 0.046, roughly that of a mountain stream. The cavern is generally less than 15 meters wide, but its height is over 100 meters. Although subsurface flow conditions are by no means uniform, typical velocities are in the order of 3 meters/second, again akin to what might be seen in a mountain valley.

The outlet, shown to the right, is located on the precipice of Migonghe River, with a waterfall drop of 46 meters.

At 964meters deep, Xiaozhai is often said to be the deepest cave in China, but the first 660 meters of this is a wide doline with a descending footpath.

Another tiankeng, Qikeng Dong, has been explored to a sump at 920 meters.

A polje is a large, flat-bottomed sinkhole, usually sediment refilled, in the Balkans, but the Slovenian designation is used internationally.

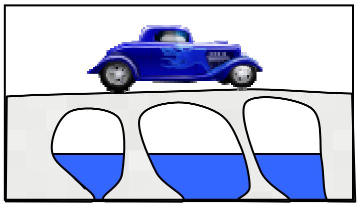
We'll include several poljes in Chapter 72, Underground and Balkanized.

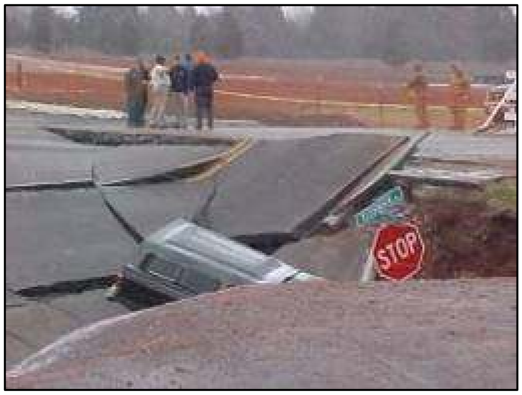
Slovenian landscape

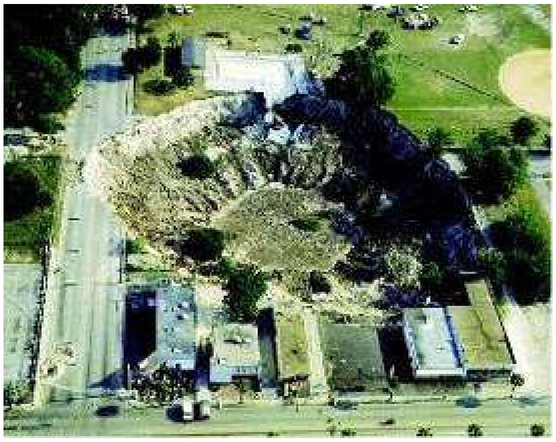
The Peril

Chapters later in our journey will enumerate a litany of dangers associated with underground rivers, but there's no better place than here to note the obvious peril of sinkholes.

Sinkhole collapse in karst terrain (Chapter 40) can be catastrophic, as illustrated by this 65-meter diameter, 10-meter-deep sinkhole in Bowling Green, Kentucky.



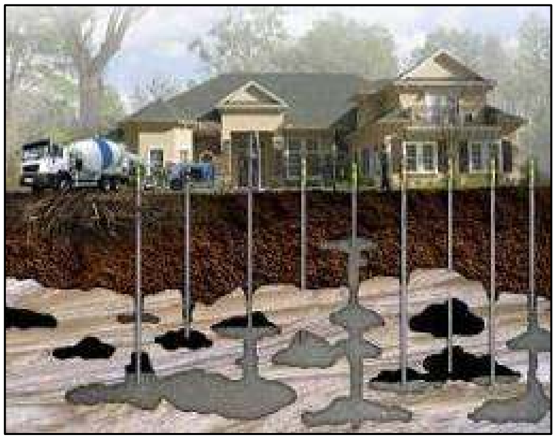


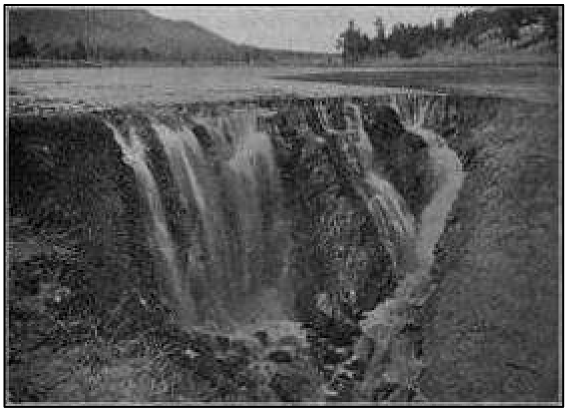


A 1981 Winter Park, Florida sinkhole, 98 meters wide and 27 meters deep, destroyed half of the city's swimming pool.

MAKE OFFER
REDUCED PRICE

How to concrete a sinkhole, at least for a while.





Or if plugging fails, market the feature.

An Introduction To Geology (1921) by William B. Scott describes a sinkhole beneath Rio de Flag near Flagstaff, Arizona

> *The "Bottomless Pit," Arizona. The stream disappears in a limestone cavern and is not known to reappear.*

The drain was a tourist attraction in the early 1900s, but the city filled it in the in the 1970s in the interest of public safety.

Sinkholes abound in chapters to come, but let us also make ourselves aware of underground rivers not flowing though karst.

CHAPTER 41

UNDERGROUND RIVERS IN CAVERNS OTHER THAN KARST

The karst cave group of the previous chapter accounts for the vast majority of what are perceived to be "underground rivers." In this chapter we'll look at other cave groups which, while generally transporting less water than do karst passages, indeed can (or in some cases once could) also harbor waterways.

In this chapter we'll look at

Lava Tubes
Sandstone Caves
Talus Caves
Mud Caves
Sea Caves
Ice Caves

The groupings are somewhat arbitrary; some are defined by mechanism of development, others by structure, yet others, by environment. A particular cavern might thus qualify for more than one designation. Our goal, however, is not one of sorting, but rather one of recognizing the subterranean waters.

Lava Tubes

Magma tends to flow as massive streams, the side-spill hardening into levees which in turn allow the free-flowing channel level to run deeper. A magma stream persisting for many hours may develop a solid crust, under which its molten fluid continues to flow like a brook beneath winter ice.

Hawaii Volcanoes National Park

Insulation of the crust allows the undercurrent to travel considerable distance before solidifying. During the 1969-74 Mauna Ulu eruptions at Kilauea, Hawaii, lava traveled through a tube exceeding 10 kilometers on five occasions.

When the volcanic source is at last exhausted or when upstream flow is diverted, the abandoned tube may drain its molten load, leaving a vacated conduit, usually with a flat floor.

A lava tube is the hardened circumference of a conduit from which its final magma load has drained by gravity. Kircher’s igneous pathways of Chapter 9 could not become lava tubes because when the eruption ceases, the remaining lava congeals in situ.

Lava tubes are found in Australia, Ecuador, the Canary Islands, Iceland, Italy, Japan, Kenya, South Korea, Portugal, Rwanda, Rwanda, Spain and the western United States. The place they're most prevalent, however, is Hawaii.

The world's longest lava tube is Hawaii's Kazumura, 65 kilometers. With more than 100 natural entrances and abundant precipitation above, the cave has an abundance of moisture, but rarely more than puddles. The 0.044 bed slope is steeper than that of many mountain streams.

World Record
Longest Lava Tube
65 km

Thurston (Nahuku) Lava Tube. Note the accumulated infiltration along the floor.

Waipouli Lava Tube. The lower several hundred meters are flooded with brackish backwater, 10 meters deep in places, from the sea.

Hawaii's lava tubes total 160 kilometers. For comparison, the state has 7,000 kilometers of roads. To compute roadway density, divide the road length by the land area. Connecticut's roadway density is 2.71 kilometers/square kilometer. Hawaii's roadway density is 0.418. Alaska's is 0.015. In the same manner, Hawaii's lava tube density is 0.010 kilometers/square kilometer. Hawaii indeed has many lava tubes, but they underlie the islands less densely than roads overlie Alaska.

"An Underground River," Scientific American, March 18, 1882, reports on Idaho's Indian Creek in the Snake River watershed.

> *Through this aperture came up from the depths below a terrible roaring, as if a leaking cataract, a mighty rush of water, tumbling over rocks. The ground trembled, and the subterranean noise continued uninterruptedly. Mete remained some time, and the longer he listened the more conceived he became that what he heard was running water, but how far down to the stream he could not even conjecture -- it might have been a few feet or half way to China.*

While the exaggeration reflects the journalism of the era, there may be some truth in the content. The site's basaltic fractures and lava tubes are extensive enough to be called "pseudo-karst" and groundwater flow is known to concentrate in such cavities.

The Great West and Pacific Coast, or Fifteen Thousand Miles by Stage-Coach, Ambulance, Horseback, Railroad, and Steamer -- Across the Continent and Along the Pacific Slope, Among Indians, Mormons, Miners and Mexicans (1877) by James F. Rusling provides this observation.

> *Snake River Station was on the north side, just at the foot of the high basaltic bluff, which here rears its majestic front six hundred feet or more perpendicularly into the air. Half way up, a*

> *small river bursts forth, and descends in a beautiful cascade two or three hundred feet, whence it rushes like an arrow down the broken, rocky hillside, and so off to the Snake itself. This fleecy waterfall, against the black basaltic bluff; is the first object that strikes you, as you descend into the valley of the Snake, and is a charming feature of the landscape just there. Our route lay along the Snake for many miles, and at several other points we observed similar cascades, on both sides of the river, though none so large or lofty as this. The conclusion seems inevitable, that subterranean streams, having their source in the far away mountains, pervade all this barren region; and could these be tapped and brought to the surface, all these plateaus might be made cultivable and fertile. No doubt a way of doing this, by artesian wells or otherwise, will be found in the future, when the continent fills up more.*

"Geologists Debate Cause of Sinking Idaho Farm," Science News Letter, August 28, 1937, illustrates what seems to be a diversity of the opinion regarding the collapse of Idaho farmland.

> *What made the cave that's swallowing up Harley Robertson's farm at Buhl, Idaho? Geologists are all agreed that the collapsing roof of a vast cavern is responsible for the sinking of over one hundred acres into an abyss more than two hundred feet deep, but none of them agree about what caused it. Local men blame an underground river, like the Lost River, which sinks into the ground nearby. Other geologists believe that the cave was made millions of years ago, when lavas poured out over the region, and hardened on top. The liquid mass below flowed on, leaving caverns, in much the same way that the filling of a pie can leak out without breaking the crust.*
>
> *Irrigation water, which brought wealth to the region, is blamed by others. Leaking irrigation water may have seeped into and carried away the underlying rocks, leaving vast caves. Still another theory is that the old channel of the nearby Salmon River, filled by the lava flows of several millions years ago, has been slowly cleared by underground streams. These cut away part of the roof, allowing the land to slump. Now it is feared that the Salmon will be diverted into underground channels, becoming a new "Lost River."*

The article's several hypotheses:

An underground river
Lava tube collapse
Underlying rocks dissolved and carried away by irrigation water
Old lava-filled channel eroded by underground stream
Lava roof above old channel cut away by underground stream

Contrary to the headline, however, there's little to debate. All explanations describe the collapse of a thin-walled lava tube after its alluvial infill has washed out.

It's not uncommon to over-estimate the hydrologic significance of lava tubes.

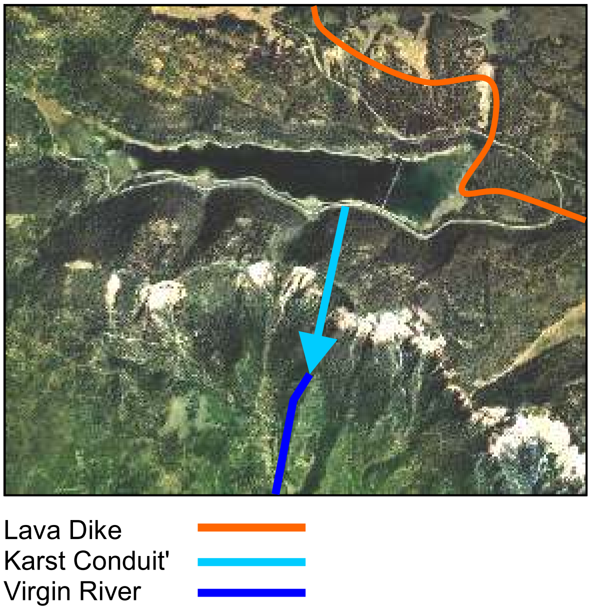
Contrary to claim that Oregon’s Rogue River derives from a lava tube, it's just a 60-meter in-and-out subterranean dip along the river's path.

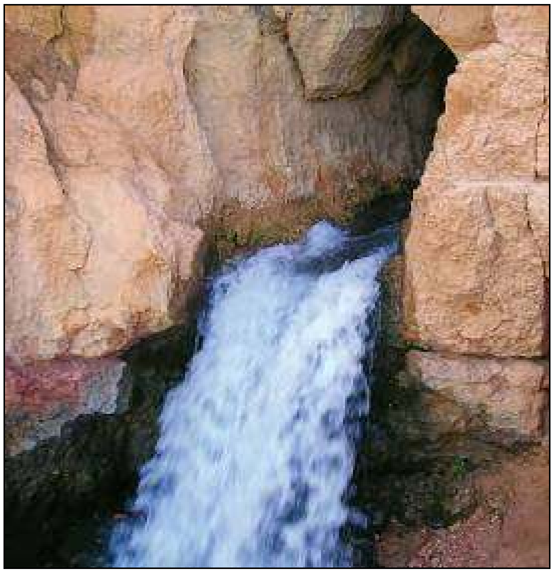
Crystal-clear Mzima Springs in Kenya's Tsavo West National Park is reputed to be "borne by an underground river" from a lava massif 40 kilometers distant. In actuality, the pathway's sponge-like ash.

The March 12, 1926, University of Illinois Daily Illini "Bottom Drops out of Kansas River. Hole Forms in Stream Bed." describes a reported 100-meter sinkhole said to be caused by volcanism, but T.T. Quirke of the Department of Geology saw it differently.

> *The volcano theory is sheer rubbish... It is improbably that the sinking bed of the stream is due to the reopening of an extinct volcano crater. The smell of sulphur is probably due to the imaginings of some persons... I doubt that it is as deep as 50 feet and it would not surprise me if it were found to be even less.*

Utah's Cascade Falls is a product of both karst and volcanism. Ancient magma backs today's Navajo Lake over a limestone sinkhole that drains to the falls 2 kilometers distant. Depending on the lake level, Cascade Falls ranges from a trickle to a torrent.





"The Devil's Kettle Conundrum," October 8, 2009, from ScienceBuzz.com illustrates another hydrologic combination of both karst and igneous process.

> *Devil’s Kettle is a puzzling geological phenomenon located on the North Shore of Lake Superior. As the Brule River makes it way toward the lake, it gets split in two by a rocky knob located just above the falls. While the east half tumbles down 50 feet in normal waterfall fashion and continues toward the lake, the west half disappears in a very large pothole and is never seen again. Where does the water go? No one seems to know.*
>
> *One theory has the river following a large fault located somewhere in the lower bedrock. But this is unlikely since it would have to be extremely large to allow for so much water to flow through it. It would also have to be precisely oriented toward the lake. And there’s never been any evidence of such a fault found in the area.*
>
> *Another theory is that a lava tube formed a billion years ago when the rocks first solidified... The problem with this theory, according to geologist John C. Green, is that the rock at Devil’s Kettle waterfalls isn't basalt -- it's rhyolite, and lava tubes never form in rhyolite.*

> *But maybe it's a hidden lava tube located in a layer of basalt directly beneath the rhyolite. After all, geologists have determined that the rocks in that particular region alternate between layers of rhyolites and layers of basalts. Maybe the swirling rock-filled glacial water that formed the pothole at the end of an ice age cut down beyond the rhyolite and into an ancient lava tube. That could have happened right? Well, not likely... North Shore basalts were flood basalts that spread out on the surface like pancake batter poured onto a griddle. But even if it were the correct kind, the nearest basalt layer to Devil's Kettle is located much too far underground to be any kind of factor in the mystery.*
>
> *So where does it all that water go? Over the years, people have tried to figure it out by throwing logs, colored dyes, and even ping-pong balls into Devil's Kettle in hopes of seeing signs of them show up along the lakeshore. But none ever has, and where it all ends up remains a mystery.*

"Where it all ends up remains a mystery." It's the mystery -- not certainty -- of underground rivers that draws us, is it not?

But truth be told, most lava tubes are relatively dry, the reasons being twofold:

> Most lava tubes are above the water table and receive only the precipitation that falls near openings.
>
> The permeability of basalt is diminished when secondary minerals, e.g., gypsum or calcite, fill the crevices. Even air-pocketed pumice has little permeability because the voids are not connected.

We'll look more closely at our biases regarding causality in Chapter 90, Why Do We Believe What We Believe?, but here we can reflect that a dark chasm related to a volcano engages us more than does a shallow depression explained by our chemistry teacher.

Sandstone Caves

Sandstone, a mix of quartz and feldspar glued with the organic residue of past sea life, is formed when layers sand are compressed by the weight of a waterbody. When the water recedes or the land uplifts, the sandstone is exposed to the elements. Unlike limestone, sandstone isn't soluble, and degradation is by the abrasion of water and impact from air-borne particles.

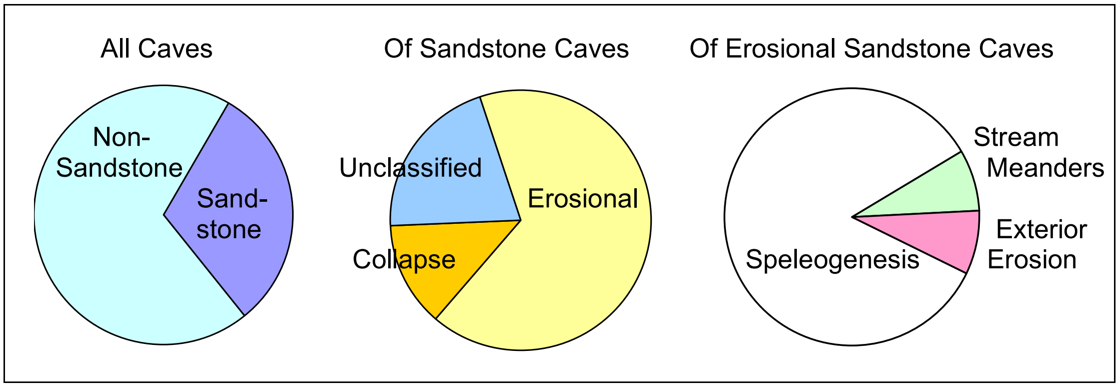
Sandstone caves eroded by wind are sometimes called "wind caves." Such caves are usually small, shallow and are often located high on cliffs. Castle Rock State Park, California

Caves formed by wave action on ocean bluffs are "sea caves," a group discussed later in this chapter. Above, Swallow Point sandstone sea cave, Sand Island, Apostle Islands National Lakeshore, Lake Superior

Most caves in sandstone, however, are by "piping," water erosion along cracks. To the uninitiated, such a conduit may resemble karst, but the genesis is entirely different. Limestone dissolves; sandstone erodes. As erosivity increases with fluid velocity and velocity increases where a pathway constricts, sandstone passages tend to wear away their tight spots.

Water may in whatever direction that cracks and pressure allow, but the net pathway will tend to slope downward to an outlet, as the eroded sand needs to vacate the conduit.

"Sandstone Caves in Wisconsin," 13th International Congress of Speleology, Brasilia, 2001, by Michael Day, reprinted in The Wisconsin Speleologist 25:1, 2002, categorizes the state's 250 mapped caverns.



Keeping in mind that we're looking at count of caves -- not the volume -- roughly a third of Wisconsin's caves lie in sandstone. "Non-Sandstone" would largely be karst.

The substantial majority of these sandstone caves are formed by erosion. As "collapsed" sandstone is the climax of erosional undercutting and "unclassified" means "unknown," the middle pie chart might just as well be entirely "erosional."

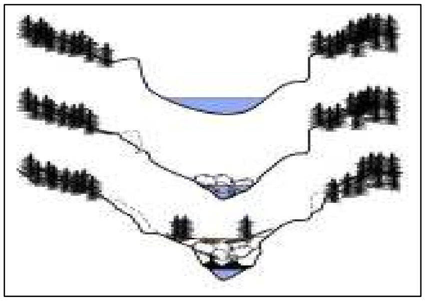
"Speleogenesis" refers to pipes within the sandstone. "Stream Meanders" is bank undercutting. "Exterior Erosion" is within surface fissures. Combining the three charts, roughly a third of Wisconsin caves are the result of sandstone piping.

Spanning more than 27 kilometers -- but not as a single thread -- the largest European network of sandstone caves is in Czechoslovakia's Broumov Walls National Nature Reserve. The photo shows bed material washed along the cave floor.

Sandstone is only infrequently associated with underground streamflow because sandstone voids rarely extend for significant distance. That's not to say, however, that we can ignore them. We'll visit the Minnesotan sandstone underground rivers in Chapter 54, Three Tales of Two St. Pauls, and in Chapter 62, More Hydropower from the Deep.

Talus Caves

Talus caves, also known as boulder, tectonic, fissure or crevice caves, are voids left amid rock rubble after the finer particles are washed out. Causes include landslide, land surface collapse, fracture, fissure and glacial action. The rock can be of any type. Talus caves large enough to enter are uncommon and recent formations can be unstable.



A washed-out depression in a boulder field doesn't constitute an underground river, of course, but where rockfall blankets a streambed and the fines erode below, a conduit may result.

If the boulders are glacial erratics, the interspersed caverns look much the same.

A fissure cave occurs where rubble bridges a crevice and the sand and gravel below is washed to the outlet.

Boulder Cave in the Wenatchee National Forest, Washington extends about 100 meters into the 10-meters-wide fissure.

Main's Allagash Caves are rock slabs detached by isostatic rebound after glacial recession. The icy environment also groups the site in a class of caves we'll discuss later.

Entrance to Bear Gulch Cave, Pinnacles National Monument, California. Fault action and erosion opened angular slot canyons that were later filled by large boulders. Flash floods are frequent.

Lost River Gorge in the White Mountains of New Hampshire disappears between granite boulders abandoned by past glaciers

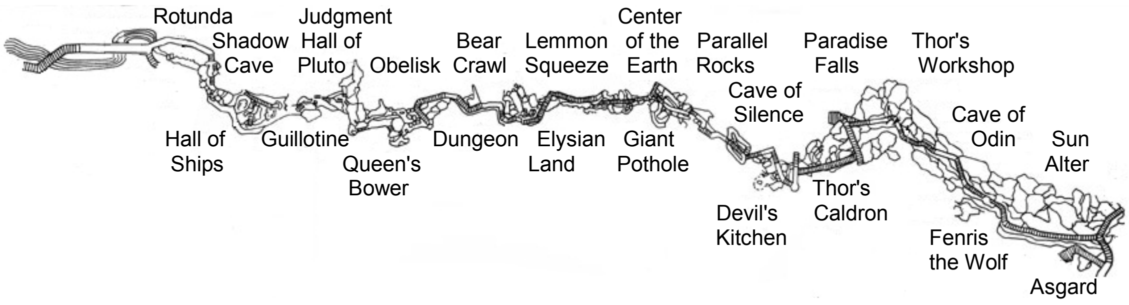
The bed of coarse gravel is typical of a steep mountain stream where turbulence washes away the sand.

The largest cave through which Lost River passes is Shadow Cave, darkly stained by iron oxides, with its 6-meter roof domed by four boulders. The steam flows as rapids 1 meter deep. The Falls of Proserpine tumbles 3 meters the end of a smaller cave.

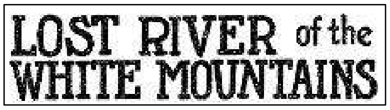
Wooden walkways, bridges and ladders make the gorge accessible. Some caves are large enough to walk through; others require agility.

SHADOW CAVE, LOST RIVER, WHITE MTS., N.H.

Lost River Gorge
$16.00

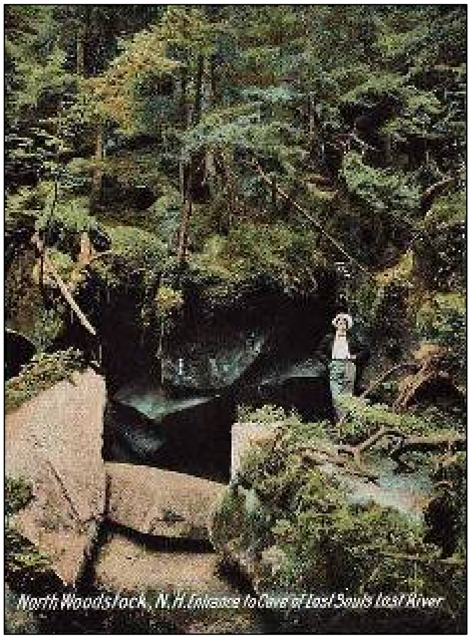

Rotunda
Shadow Cave
Judgment Hall of Pluto
Obelisk
Bear Crawl
Lemmon Squeeze
Center of the Earth
Parallel Rocks
Paradise Falls
Thor's Workshop
Cave of Silence
Cave of Odin
Sun Alter
Hall of Ships
Guillotine
Queen's Bower
Dungeon
Elysian Land
Giant Pothole
Thor's Caldron
Devil's Kitchen
Fenris the Wolf
Asgard

Excerpts from 1912 travelogues capture the visitor's impression. First, "Lost River of the White Mountains," Akron Weekly Pioneer Press, July 19, 1912,


LOST RIVER of the
WHITE MOUNTAINS

> *It is only within the last few years that Lost River, its marvelous series of caves and caverns, its shady pools and silvery waterfalls have become at all well known even to the more ambitious travelers. It is expected that increasing numbers of raincoated, rubber-booted devotees will soon make the fascinating underground journey along this strange stream as it dips and winds its way far beneath the surface.*
>
> *The little stream takes its rise on the steep slopes of Mount Moosilauke. Darting downward in its rush to the waters of Pemigewasset in the valley below, it plunges into great vaulted caverns of limestone, now and then losing itself in subterranean passages so far in the heart of the earth that even the murmur of its waters fades from the ear.*
>
> *For a mile or more the bed twists between and beneath great masses of rock through strange passages and widening chambers... Emerging into the bright sunlight for a few miles, it soon disappears over some high precipice and then dives so deep down into the bowels of mother earth that not even the distant sound of its waters can be heard. This place is appropriately called the Cave of Silence.*
>
> *Birchbark torches are carried to light up the dark caverns... On it goes, through Plato's Judgment Hall, where the light streams dimly through, making a perpetual twilight within. The huge masses of rock which form the roof are jumbled together in every conceivable shape. Many more caves follow... Fat Man's Misery is passed with great difficulty by the stout visitors, on account of its narrow entrance.*
>
> *Part of the way through the gorge is Paradise Falls, one of the most beautiful of its size in the entire White Mountain region. At this point the stream emerges into the open for a plunge of 39 feet and then enters another series of glacial caverns below.*

Narrative by Justis Conrad is similar. To the right is a 1908 postcard.


North Woodstock, N.H. Entrance to Cave of Lost Souls Lost River

> *The next is a "presto chango"* [a change occurring suddenly and as if by magic] *act through a small tunnel into "Shadow Cave." This is a large room into which fifty people can gather, and by use of torch view the little river as it glides along beneath big boulders on the northern side...*
>
> *We view "The Guillotine" and pass swiftly on down over another series of ladders into "The Judgment Hall of Pluto," which is fifty feet lower than the point of entrance into the gorge... The architecture of this room is magnificent, boulders of every conceivable size and shape hanging from overhead. What is it we hear? We listen, look, a torch is lighted, we rush forward. There at the northern end of the hall, back behind a gigantic boulder, the "Falls of Proserpine" are tumbling for twenty feet, while we are showered with a cooling mist....*
>
> *Again we retreat up a long ladder and emerge into "Elysian Land" on the exterior, where the river glides gracefully along the moss covered rocks soon to be lost, however in the "Center of the Earth cave."*

> *Again we pass over a series of well kept walks and bridges through "Elysian Land" and hide ourselves in the "King's Chamber," from whence we can view by the use of a torch the deep pool in the "Center of the Earth Cave." This a large cave in which a small boat could float... It is at this point that the river is so much lost that no one has yet been able to absolutely determine its exact course.*
>
> *We now enter the "Cave of Lost Souls" and, while the name might make us shudder, we continue on and find that this is a continuous series of rooms accessible to any that do mind a hard stunt... Retreating from this cave, we climb to the "Upper Bridge" that spans the gorge twenty feet above the bottom. From this point we look into "The Gulf" forty feet below in to which the waters of "Paradise Falls" tumbles perpendicularly for twenty feet...*
>
> *Eventually we pass to the "Lower Bridge" that spans the gulf, from whence we vies the "Long Lost River" as it emerges from the "Cave of Silence" and the other caves beyond.*

Bulgaria's Devil's Throat, a talus abyss formed by tectonic collapse, is entered via a 150-meter artificial tunnel. The cave's length is 1 kilometer, of which a third has an improved path. This cave contains numerous underground waterfalls, the largest, 42 meters in height.

Roughly 400 meters from the entrance, the stream disappears into a funnel 150 meters deep, emerging in a second cavern. Dye tests indicate a 90 minute travel time, more than the distance seems to merit, and floating objects do not emerge. The subterranean linkage is obviously complex.

It is via Devil's Throat that Orpheus is said to have descended into the Kingdom of Hades in search of his beloved Eurydice.

Devil's Throat
BGN 3.00

Mud Caves

Mud caves form where sediment has washed from beneath a mass of silt and debris. Unlike talus caves where larger stones maintain the roof, perpetual flow in mud caves would down-cut the bed and collapse the route. These caves thus only exist in arid regions.

Arroyo Tapiado in Southern California's Anza Borrego State Park has some of the most extensive mud caves in the world, some more than 300 meters deep with chambers up to 24 meters in height.

China has "mud caves," but most are clay-rich pools impounded in karst cavities. As for the advertised therapeutic benefits, the experience indeed appears to be fun.

Sea Caves

A sea cave, also known as a littoral cave, is a cavern enlarged by wave erosion. Sea caves occur in formations ranging from sedimentary to metamorphic to igneous; it's the relentless sea that makes them a group.

Active sea caves are tidal -- as opposed to being unidirectionally traversed from only an inland source. Some can only be approached by boat, while others drain at low tide and can be explored on foot. Emerged sea caves are those opening below the surface of the ocean. Other sea caves are far inland, artifacts of ancient waters.

Anemone Cave, Acadia National Park, Maine, was once an official part of the sights ofthe park for a long time, but officials removed the cave from most publications to protect the cave from too many visitors.

CardCow.com

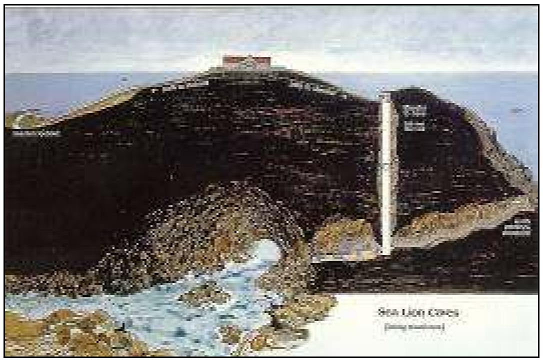
1949 Postcard

Sea caves are rarely deep, with only a few exceeding 300 meters in length. Below are the world's three longest, all of which are in basalt.

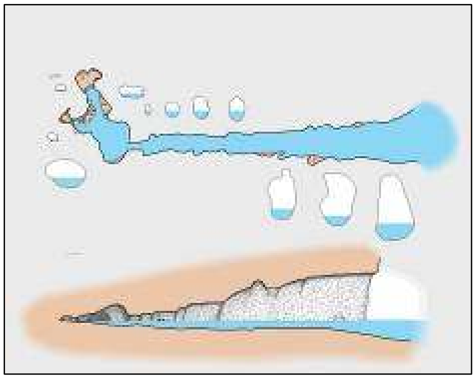
	Location	Meters
Sea Lion Cave	Oregon	401
Painted Cave	Santa Cruz Island, California	374
Waiahuakua Cave	Kauai, Hawaii	352

Sea Lion Cave was discovered in 1880 by small boat. The ocean continually washes into the 0.8-hector cavern under a 38-meter rock dome.

Photo from 1952

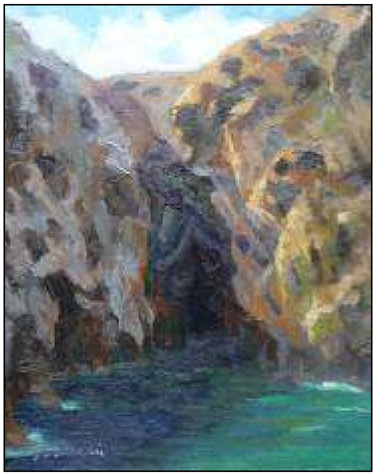
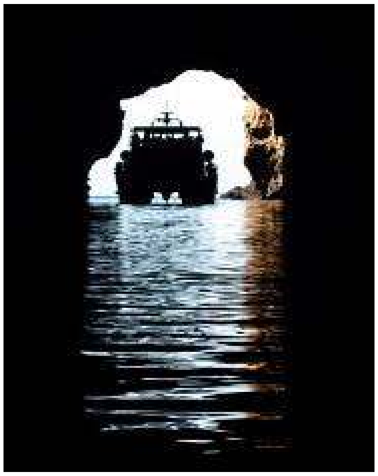


The elevator was added in 1961.



Painted Cave, Santa Cruz Island, California was reported in the Overland Monthly, December 1891.

> *The largest cave, called Painted Cave, on Santa Cruz Island is near the northwestern curve, and was lately discovered. Last month Captain Brownsill of the sloop Big Loafer, guided a small party of us to explore this immense cavern. We rowed in, in a small skiff, through a succession of arches resembling those of a gothic cathedral. When about fifteen hundred feet from the entrance the cave branches off to right and left.*
>
> *From lack of proper torches, in the utter darkness we could not fully explore to the ends. The entire visible interior is brilliant with natural frescoes in color, made by mineral waters oozing through the porous rock. There was no beach, and the inner cave is closed at high tide. It is a sea lions' den.*

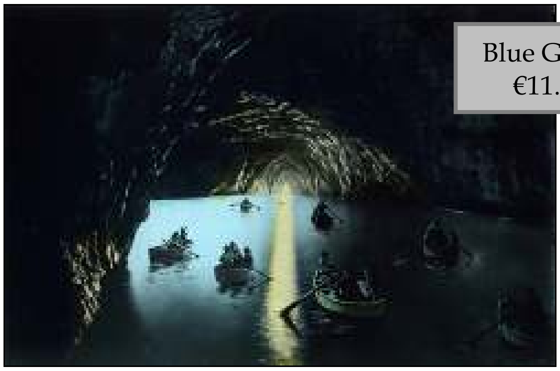
		
Painted Cave from without. 2011 oil by Marian Fortunati	Painted Cave from within	Waiahuakua Cave

Hawaii's Waiahuakua Cave has two entrances between which one can kayak when the tide permit. A waterfall enters the cave through a skylight. A bit of local lore from On the Nā Pali Coast: A Guide for Hikers and Boaters (1988) by Kathy Valier,

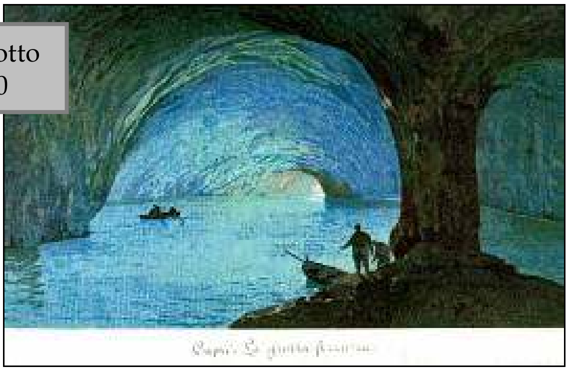
> *Boat captains like to thrill their passengers by charging at full throttle in to the dark recesses of the cave, making a quick turn at the last second, then darting our a back entrance that leads to the sea... A tale recounts how a Hawaiian fisherman took advantage of the cave's back entrance to evade some oceangoing robbers. Six men in a canoe gave chase to this fisherman who was returning to Haena with a boatload of fish. Seeking refuge in the westernmost cave, he quietly paddled around and out the other entrance, while his pursuers, ignorant of the cave's second entrance, waited patiently for him to reappear.*

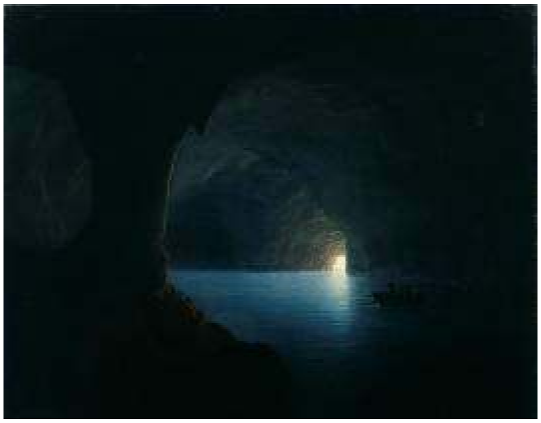
The world's best-known sea caves are the Italian Isle of Capri's luminescent Blue Grotto and the foreboding Fingal's Cave on the Scottish island of Staffa.

The Blue Grotto, 155 meters in length, is a karst formation.



Blue Grotto
€11.50

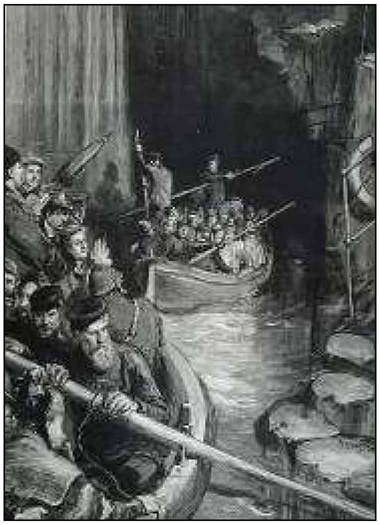




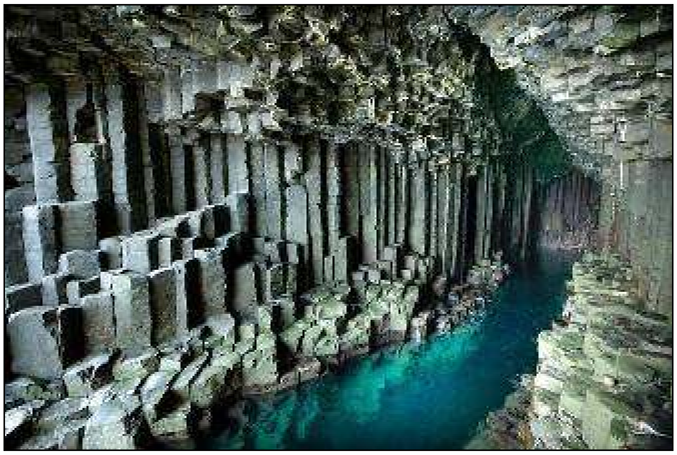
The Blue Grotto was known to the ancients, as evidenced by the statue of the Greek god Triton left to guard the site.

"La Grotte Bleue à Capri" (1860) Carl Friedrich Seiffert

Fingal's Cave was brought to the attention of the English-speaking world by the 18th-century naturalist, Sir Joseph Banks. The cave passes between hexagonal basaltic columns created by a magma cracked in a manner similar to that of drying mud, the fissures extending downward to form columns subsequently exposed by erosion.



Fingal's Cave, 1892



Fingal's Cave
£25.00

Estimates of the cave's length illustrate the subjectivity of measuring a system of tidal flux.

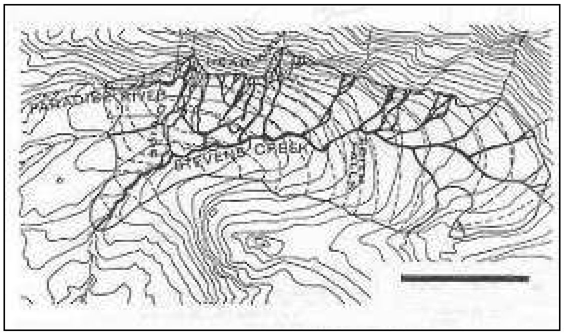
Reference	Meters
Wood-Nuttal Encyclopedia (1907)	69
National Public Radio	45
Show Caves of the World	85

Ice Caves

Ice caves are of two types: those formed of ice, often designated as "glacial caves," and those containing ice.

Melted-out cavities within a glacier can be extensive and change shape rapidly. Frequented by turn-of-the-century excursionists, Mt. Rainier's Paradise Ice Caves were thought to have since disappeared. In 1978, however, ice cavers measured 13.25 kilometers of passageways.

Paradise Ice Caves Visitors, 1930s



Paradise Ice Caves, 1982 Survey

Ice Cave,
Three Sisters Wilderness, Oregon

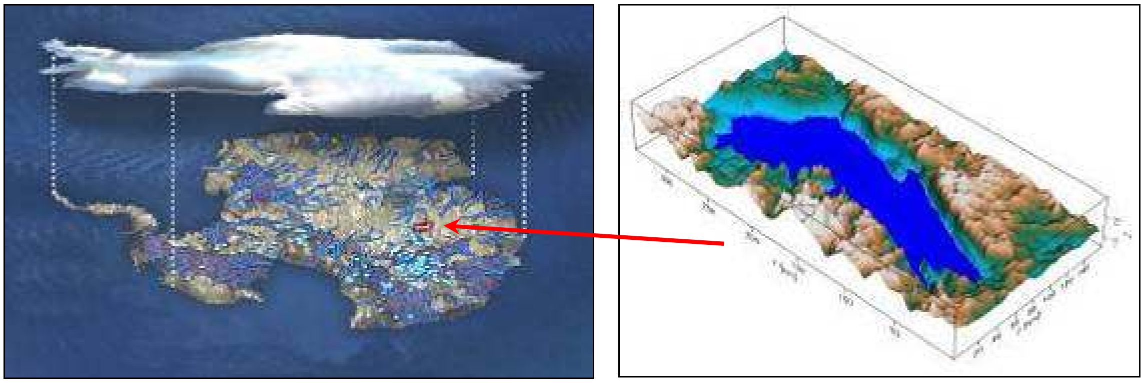
For visual comparison: "Crystal Cave," computer generated for the game The Ghost Town of Caramin. Nature can evoke the same sense of fantasy.

Antarctica has vast underground rivers. From Reuters, April 20, 2006,

> *Scientists have found huge, powerful rivers that may connect subglacial lakes deep under the Antarctic ice.*
>
> *UK researchers who discovered the plumbing system that moves water hundreds of kilometers say it challenges the notion that the lakes under the Antarctic ice evolved independently and could support ancient life.*
>
> *"Previously, it was thought water moves underneath the ice by very slow seepage," says Professor Duncan Wingham of University College London who headed the research team.*
>
> *"But this new data shows that, every so often, the lakes beneath the ice pop off like champagne corks, releasing floods that travel very long distances."*

> *About 150 subglacial lakes have been discovered in Antarctica but researchers believe there could be thousands. Lake Vostok, at 15-20 million years old, is thought to be the oldest.*
>
> *"The lakes are like a set of beads on a string, where the lakes are the beads connected by a string or river of water," says Wingham. The scientists believe when the pressure in one of the lakes increases, a flood fills the next bead down the string.*

Some 150 underground Antarctic lakes such as 14,000-square-kilometer Lake Vostok -- think of Lake Ontario under 2,000 meters of ice -- are connected by radial underground rivers.

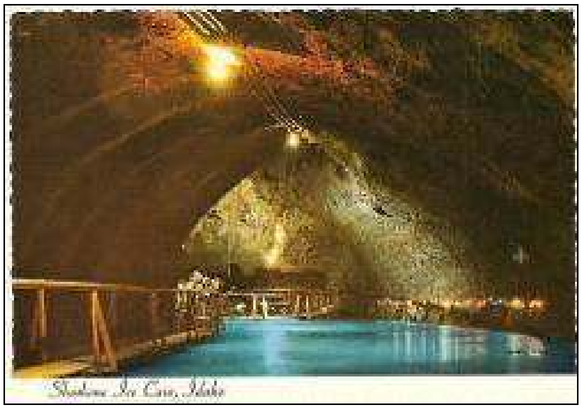


When the Russians, drilling since 1991, finally strike the hidden lake, we'll have a pristine sample of our planet's environment 15 million years in the past.

The second class of ice caves is that of hard-rock caves in which water freezes. The cavern itself may be of any origin.

Dobsina Ice Cave, Slovenia

SLOVENSKO
1,10€
DOBŠINSKÁ ĽADOVÁ JASKYŇA



Shoshone Ice Cave, Idaho

Ice Skaters, Merril Cave, Lava Beds National Monument, California, 1930s

Lava tube cave with permanent ice floor, El Malpais National Monument, New Mexico

The floor of Beauty Cave, Craters of the Moon National Monument, Idaho, can be a sheet of ice covered by several centimeters of water.

CHAPTER 42
SUBMARINE SPRINGS AND RIVERS

Submarine Springs

We can demonstrate with just a few references how our understanding of submarine springs has followed much the same path as our understanding of subterranean rivers.

We have the classical references.

In Chapter 1, Greek Mythology, reference to "a powerful submarine source" said to cause a whirlpool off the coast of Epirus. In Chapter 3, Roman Encyclopedists, a table of purported fresh water springs beneath the oceans.

Strabo's Geographia mentions a spring 20 meters below the straits of Aradus, Syria, an island otherwise without potable water. A leather hose fitted with a lead hemisphere was let down over the spring opening and fresh water rose in the pipe to a floating vessel

In Natural History, Pliny the Elder describes the Black Sea.

> *This is rendered more remarkable by springs of fresh water bubbling out as if from pipes on the seashore. In fact the nature of water also is not deficient in marvels. Patches of fresh water float on the surface of the sea, being doubtless fighter.*

We likewise have the Biblical validation.

Job 38:16	*Have you entered into the springs of the sea?* The word for "springs" more commonly refers to the places where water issues from the earth.
Genesis 7:11	*Fountains of the great deep were broken up and the floodgates of heaven were opened.* The noun "fountains" is used for freshwater springs in many Old Testament passages. The "deep" is employed in Genesis 1:2, where God's Spirit broods upon the face of the waters.
Proverbs 8:28	*When he made firm the skies above, and the springs of the deep became fixed.*

As the Scientific Revolution tended to be more concerned with terrestrial geology than with oceanography, submarine springs drew less attention from early geologists, but as the nature of springs upon the earth became at last understood -- a convoluted learning process, to be sure -- the theory of submarine springs fell into place.

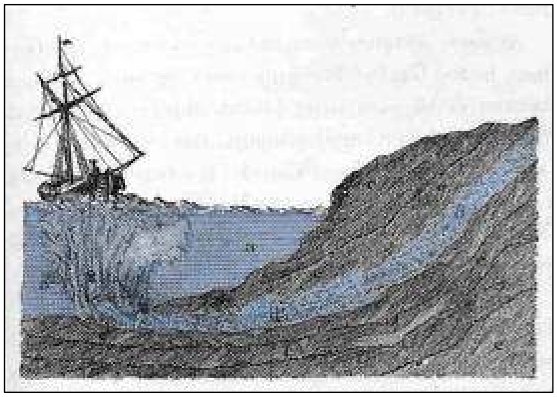
While the idea of water beneath land in turn beneath water is engaging, the physics within such a conduit is the same as that within a conduit under dry earth. Submerging the outlet simply decreases the energy gradient, and thus the rate of flow. From In the Realm of Nature (1908) by H.R. Mill,

> *"In all limestone regions rivers disappear beneath the surface, and although some reappear on land, several vanish altogether, and ultimately well up through the salt water of the sea, sometimes from depths of 100 fathoms* [180 meters] *or more.*

The source of submarine springs, as illustrated by Leon Sonrel's The Bottom of the Sea (1870):

(aa) Sea Water;
(bb) Fresh Water;
(cc) Impermeable Strata;
(dd) Permeable Stratum in which the Fresh Water Flows.

While the graphic may be overly dramatic, the logic is conceptually correct.



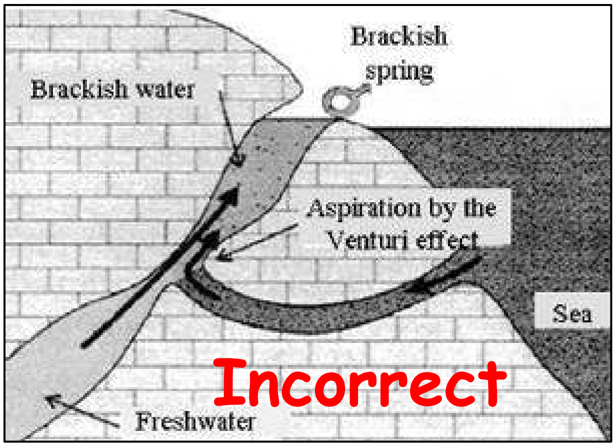
Sonrel's examples, all from the Mediterranean, convey great detail regarding such springs -- not all accurate, perhaps, but distinctively engaging.

> *The return of the water to the surface takes place under the sea no less than on continents, as proved by numerous observations of submarine springs of fresh-water. Many such have been remarked on the Mediterranean littoral. According to M. de Villeneuve-Flayosc, those which we find between Perpignan and Spezia* [Italy]*, at a distance more or less great from the shore, deliver some 50 cubic meters every second, which is about one-third of the quantity of water delivered by the Seine in the same time.*
>
> *In the Gulf of Spezzia, at the distance of 60 or 70 yards from the shore, we see a kind of swelling in the sea -- it extends over a space about 80 feet in diameter, and is something less than six inches in height. When the sea is calm, it is easy to see vertical jets of water springing from the bottom. This water is found to be fresh, and it comes from a submarine spring. Its superior lightness causes it to reach the surface of the sea before the salt-water has time to affect it.*
>
> *At some distance from the embouchure of the Galaso, in the Gulf of Tarentum* [also Italy]*, there springs from the bottom of the sea a jet of fresh-water so powerful that it can be procured without mixture with the saltwater. A similar jet exists in the famous salt-pool of Thau, near Cette (on the Mediterranean coast of France); here the fresh-water rises so rapidly that it produces waves.*
>
> *What may be called a true subterranean river debouches under the sea near Ragusa* [Sicily]*. There are sweet water springs in the ports of Cattaro* [Montenegro] *and Aulona* [Albania]*, near the embouchure of the Acheron, in the midst of the sea; over a space of 40 feet in diameter fresh-water is thrown up abundantly with great force. This is probably the same spring of which Pausanias speaks.*
>
> *A stream of fresh-water springs from the bottom of the sea near Tortosa, on the coast of Syria. Its force is so great that the sweet water can be taken without mixture with the salt. Pliny speaks of a similar phenomenon near Arcadus.*
>
> *The Gulf of Argos* [Greece] *supplies an example of a very abundant source of fresh-water named Anavolco, and situated between Kiveri and Astros. Ancient writers affirm, though this may be a little uncertain, that it has been in activity some 1700 years. Colonel Leake, a traveler remarkable for his minute observation, informs us that the column of fresh-water appears to be not less than 50 feet in diameter. When the atmosphere was calm he observed that the water rose with such force from the bottom of the sea as to swell the surface, and agitate it in concentric circles to a distance of some hundreds of feet. He attributed this to the embouchure of a subterranean river at the bottom of the sea.*

We've subsequently garnered oceanographic data regarding the phenomenon, but the basic logic of Sonrel's ship dashed about by the upwelling remains unchanged.

That doesn't imply that we always get it right, however, even today.

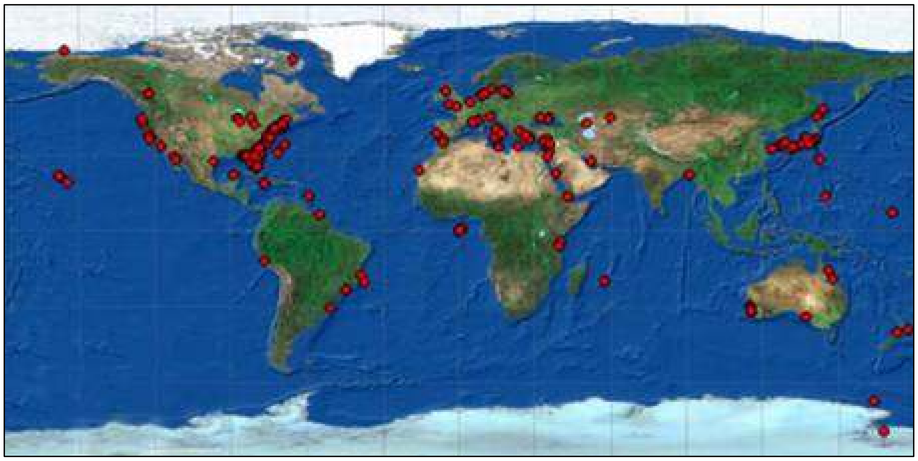
A "Venturi-effect" explanation for seawater channelized to an above-sea-level spring was proposed by Otto Lehmann, Die Hydrographie des Karstes (1932) and repeated in "Submarine Springs and Coastal Karst Aquifers: A Review," Journal of Hydrology 339:1-2, June 2007, by Perrine Fleury, Michel Bakalowiczb and Ghislain de Marsilyc.



It's a physical impossibility. Flow direction is not determined by pressure alone, but by total energy differential. Flow in the sea-linked conduit must be toward, not from, the ocean, the proof of which can be given by first-year engineering students.

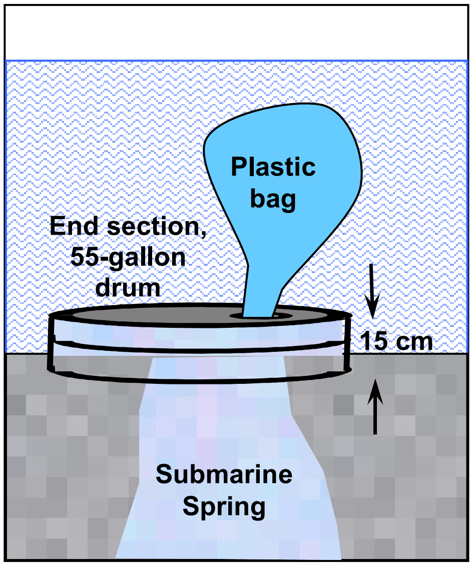
Shore-side springs can be brackish, of course, but it's due to underwedged intrusion and upward ionic diffusion.

There are several hundred major submarine springs on the earth, some of which are shown to the right.



Even in a quiescent sea, freshwater introduced from a point on the floor disperses to a lateral diameter roughly equivalent to the height risen. Measurement of the input thus needs to be at the source.

To the right is a submarine spring gaging apparatus, straight-forward in concept, but suitable only for a shallow and localized discharge. Larger scale esitmates are usually by indirect methods and can vary widely.

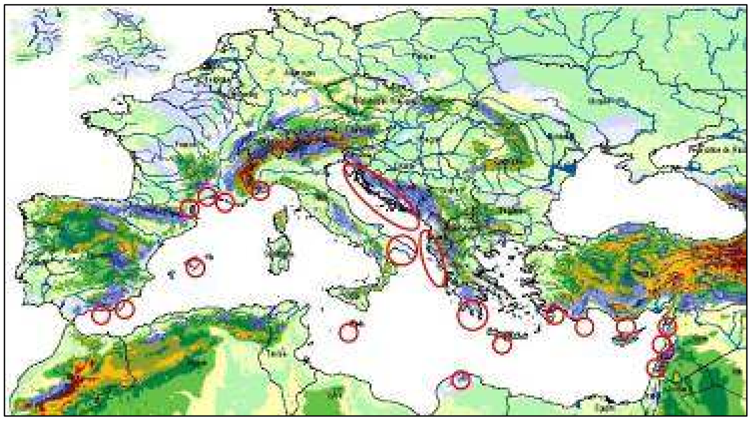


Global estimates of groundwater discharge to the ocean tend to be between 6 and 10 percent of the freshwater input, the bulk via diffuse aquifer seepage, not distinct seabed springs.

Even a small upwelling from a minimally-submerged karst spring, on the other hand, is likely to be noticed. Local studies, of which there are only some 40 world-wide based on direct measurement, tend to show groundwater in greater portion, not an unexpected finding, given that such investigations focus on known spring zones.

Percent of Freshwater Input	Location
20 to 35	Long Island, New York
20	Great South Bay, New York
30	South Cape Cod, Massachusetts
87	Buttermilk Bay, Massachusetts
40	Carolinas
Essentially 100	Rhode Island
10	Chesapeake Bay, Virginia
17	Swan River Estuary, Western Australia
29	Adriatic Sea
75	Mediterranean

Most submarine freshwater conduits are the result of terrestrial karst process that occured some 10-20,000 years ago when sea was 120-140 meters below its present level.



In the Mediterranean, the waterbody most studied for submarine strings, karst comprises 60 percent of shoreline, the major zones shown in red.

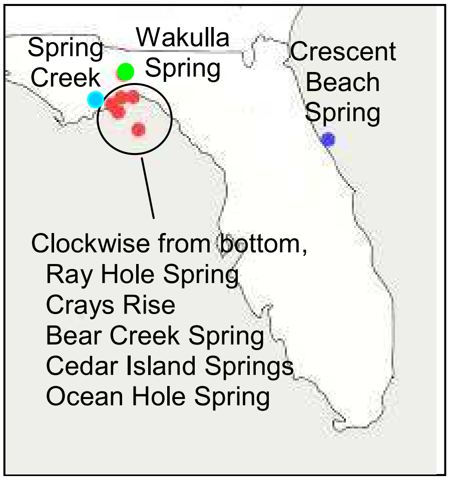
As a general rule, the largest submarine springs tend to be close to shore, often in the intertidal zone. The spatial distribution decreases somewhat exponentially from shore.

We've mentioned a few such springs earlier in our journey and will come across others, but here we'll visit a few special cases.

Ojos

The submarine springs, known as "ojos," occur along the eastern coast of the Yucatan Peninsula. The discharged water has lower pH than the surrounding seawater, reducing the concentration of carbonate ions and making it harder for organisms such as corals to build structure.

Florida



Numerous springs and seeps occur off the coast of Florida, but only 15 are documented, most of them being off the west coast. Most are near land, but one is 30 kilometers offshore.

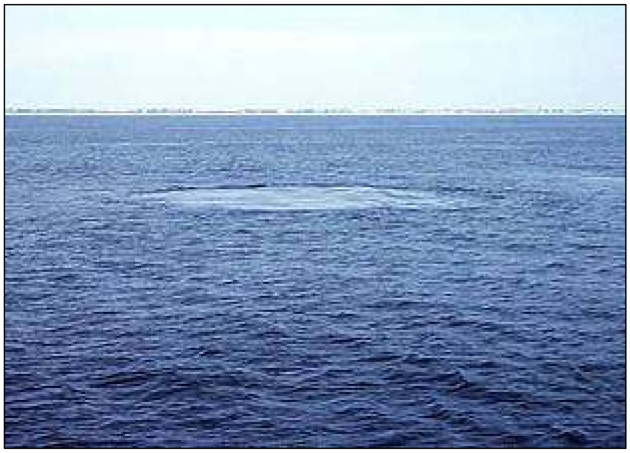
Wakulla Spring, a land-enclosed feature, will be discussed in Chapter 52, The American Tourist Trade, but here we'll mention the downstream cluster of more than a dozen estuarine springs collectively known as the tongue-twisting "Spring Creek Springs Group" known for their surges of upwelling turbulence.

Total flow is in the order of 60 cubic meters/second. There are no measurements of individual springs, but some could exceed 12 cubic meters/second.

At low tide, the boil from Spring Creek #10, 25 meters across and several centimeters above the general water surface, is both visible and audible from 100 meters away. Eruptions are up to 30 centimeters high and 5 meters in diameter. The spring is said to disgorge plants, freshwater fish, and even garbage.

Crescent Beach Spring, 4 kilometers off Florida's Atlantic coast and roughly 18 meters beneath the surface, can be detected by the appearance of a slick at the water surface due to the shimmering of the salinity contrast.

	Chloride (mg/l)
Crescent Beach Submarine Spring	3,630
Seawater	19,400



Elisee Reclus describes the Crescent Beach submarine spring in The Earth: A Descriptive History of the Phenomena of the Life of the Globe (1871).

> *The shores of the United States, the calcareous soil of which is probably pierced with caverns from the very centre of the continent, perhaps are the coasts which pour into the sea the most abundant subterranean rivers. Near the mouth of the stream of St. John, a submarine stream of perfectly pure water spouts in bubbles as far as one to two yards above the level of the sea.*

As we note in Chapter 79, Veins of the Hartland, it was widely believed that the American interior was drained by subterranean rivers. The uniqueness of our quotation lies in the vastly exaggerated bubbling height of "one to two yards above the level of the sea," at St John.

Reclus includes an American-favorite hydrologic comparison also mentioned in Chapter 79, flow greater than that of the Mississippi.

> *The month of January, 1857, all that part of the sea which is adjacent to the southern point of Florida was the scene of an immense eruption of fresh water. Muddy and yellowish water furrowed the straits, and myriads of dead fish floated on the surface and accumulated on the shores. Even in the open sea the saltness diminished by one half, and in some places the fishermen drew their drinking water from the surface of the sea as if from a well. It is affirmed by all those who witnessed this remarkable inundation of the subterranean river that, during more than a month, it discharged at least as much water as the Mississippi itself, and spread over all the strait, 31 miles wide, which separates Key West from Florida.**

A visible indication similar to the Crescent Beach photo is noted in historical references to submarine springs near Australia.

From The Dead Heart of Australia: A Journey around Lake Eyre in the Summer of 1901-1902, With Some Account of the Lake Eyre Basin and the Flowing Wells of Central Australia (1906) by John Walter Gregory,

> *Along the Bight there are many submarine springs of fresh water; and when the sea is still, there may be seen swirling, ascending columns of a material, that is said to look like oil; but no oil can be found upon the surface.*

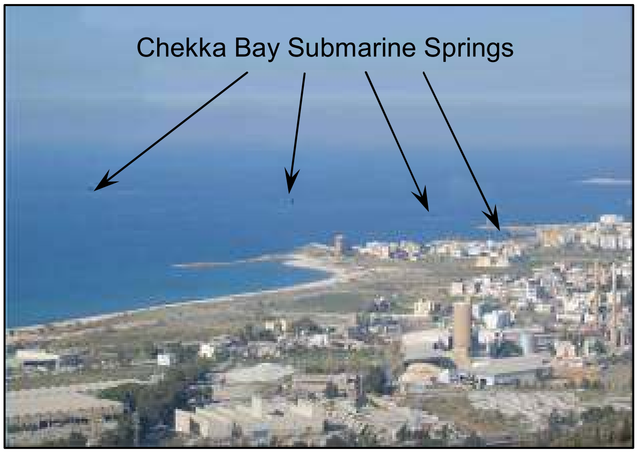
And from "Submarine Gullies, River Outlets, and Fresh-Water Escapes Beneath the Sea-Level," Geographical Journal 14:4, October 1899, by Henry Benest,

> *The aspect of the surface waters goes to show that from some cause, probably artesian, considerable disturbances take place on the bed of the sea along the Coromandel, Ceylon, and Malabar coasts. At several points stretches of muddy water, colored yellow or red, have been seen, even in great depths. The waves break around the edges of these spaces, within which the surface always remains smooth, or slightly disturbed in an undulating form.*

We'll learn more of Benest's thoughts in Chapter 70, On Some Repairs to the South American Company's Cable.

Turkey

Chekka Bay in Turkey contains freshwater springs from the Taurus Mountains.



The table below, adapted from "Submarine Springs and Coastal Karst Aquifers: A Review," Journal of Hydrology 339:1-2, June 2007 by Perrine Fleury, Michel Bakalowicz and G. Demarsily, provides a few comparisons.

Submarine Spring	Fontaine d'Yport	Mortola system	Chekka	Port Miou	Moraig system	Anavalos Kiveri	Thau system	Crescent Beach
	France	France, Italy	Lebanon	France	Spain	Greece	France	Florida
Distance to shore (m)	0	800	100 - 1000	0 (cliff side)	0 (cliff side)	< a few 10s	100	4000
Depth (m)	1.4, high tide	35	10 - 150	12	12	0 - 7	31	18
Salinity (mg/l)	Fresh-water	< 1000	1000 - 20,000	6000 - 20,000	7000 - 22,000	300 - 25,000	< 3000	6
Discharge (m3/s)	3	0.03 - 0.2	A few 0.01s - 60	1 - 10	0.3 - 9	10	> 0.1, low flow	42
Karstification	Poorly developed. System similar to fractured aquifer.		Well-developed below sea level and open to the sea. Conduits too large compared to present flow. Insufficient freshwater head to prevent seawater intrusion.			Well-developed below sea level, partially or totally closed to the sea. Uncontaminated by seawater due to clogging or impermeable confining layer		

Bahrain

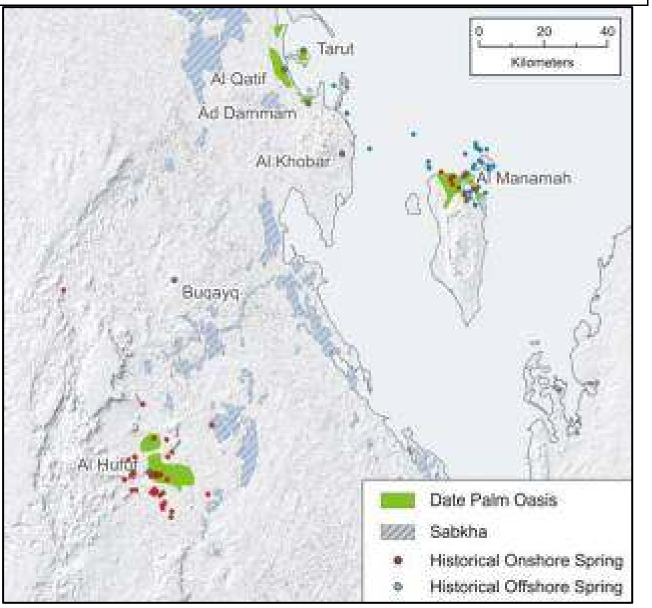
The island of Bahrain in the Persian Gulf had long been noted for its submarine springs.

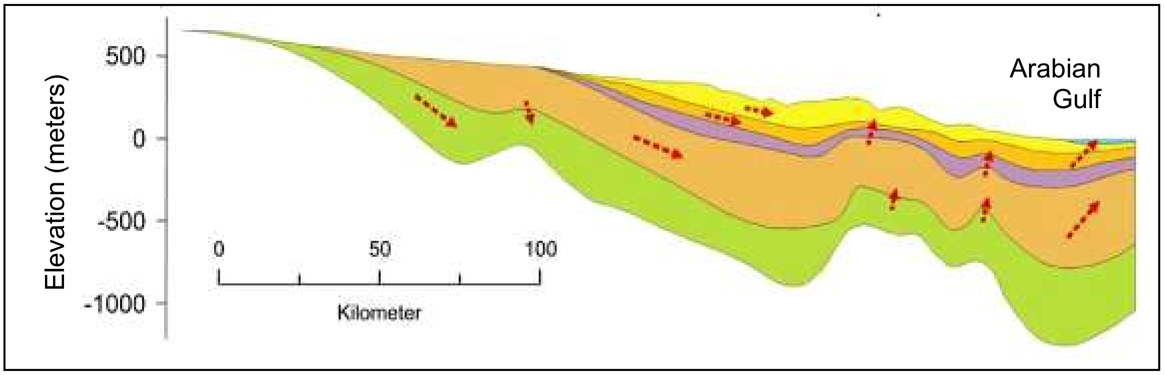
"Fresh Water Springs at the bottom of the Sea," Museum of Foreign Literature and Science, Jan-June, 1830	*On the western and north side of Arad, at some distance from the beach, are springs of fresh water gushing from the submarine rocks, where the salt water flows over them at a depth of a fathom or two, according to the state of the tides. Some of the fresh water springs are close by the beach and here the fishermen fill their jars and tanks without difficulty, but many of the springs are distant from the shore; and whenever the fishermen on the bank near them require water, they bring their boat over the spring, and one of them dives under the surface of the salt water with a leathern mussuck, or tanned skin of a goat or sheep, and places the mouth of it over the spring. The force of the spring immediately fills the bag with fresh water, and the man ascends without difficulty to the surface, and empties his cargo into a tank, and he descends continuously to replenish his mussuck, until the tank is filled. Captain Maughan was told that some of these springs are in three fathoms of water. The mussuck they use may contain from four to five gallons; the people who generally fish about these islands are pearl divers, accustomed to dive in twelve and fourteen fathoms for pearls... There are also springs of fresh water under the sea near the north-eastern part of Bahrain island. From all that Captain Maughan could learn, about thirty springs of fresh water have been discovered in the sea in the neighborhood of Bahrain and Arad.*
"A Queer Way to Get Fresh Water," Christian Advocate; July 9, 1885	*When a man's wife calls him to go after a pail of water, and be quick about it, over in Bahrin, he grabs a goatskin bag, yells at the first neighbor he sees stretched out in the sand, and the two jump into the boat and row a short distance.*
"The Hottest Spot on Earth," Friends' Review; a Religious, Literary and Miscellaneous Journal, July 15, 1886	*At Barrin the arid shore has no fresh water, yet a comparatively numerous population contrives to exist there, thanks to the copious springs which burst forth from the bottom of the sea. The fresh water is got by diving; the diver, sitting in his boat, winds a goatskin bag around his left harm, the hand grasping its mouth; then he takes in his right hand a heavy stone, to which is attached a strong line, and thus equipped he plunges in and quickly reaches the bottom. Instantly opening the bag over the strong jet of fresh water, he springs up in the ascending current, at the same time closing the bag, and is helped aboard. The stone is then hauled up, and the diver, after taking his breath, plunges in again. The source of these copious submarine springs is thought to be in the great hills or Oman, some 500 or 600 miles distant.*
The Persian Gulf Pilot (1898), Hydrographic Department, Great Britain	*H.M. Schooner Mahi, I.N., lay sheltered from all winds, and filled up with water by means of a pipe and hose which conveyed water through the sea into the boat, the vessel lying within a quarter mile of the spring.*
"Bahrein: Port of Pearls and Petroleum," National Geographic, February 1946, by Maynard Williams	*Another way to catch water is through a bamboo tube. The tube is stuck endwise and pressed against the submarine source until potable water boils up several inches above the harbor level.*

"Land of the Two Seas," Saudi Aramco World, November 1964, by Keith Bradley	*The lithe brown figure took a deep breath, clutched the deflated goatskin bag to his chest, and leaped from the prow of the jalibut into the sea. Down he sank to the bottom, some three fathoms below the calm surface, and for a full half-minute remained submerged among the undulating flora of the deep. Then suddenly he broke surface, heaving the now-swollen goatskin bag into the eager hands of his shipmates.* *The goatskin passed from one sailor to the next, each in turn slaking his thirst -- not with salty sea water, to be sure, but with cool fresh water issuing from one of the many submarine springs which ring the Arabian Gulf island of Bahrain. Indeed, the presence of sweet water beneath the briny sea is thought by philologists to account for the name Bahrain itself -- an Arabic word meaning "two seas," and referring to the ancient assumption that there was another sea beneath the sea bed.*

The submarine springs are believed to be derived from sources in Saudi Arabia, 120 kilometers distant.

The flow is as confined groundwater, however, not a distinct channel. The sedimentary succession consists of partially-connected karstified fractured bedrock of carbonates, sulfates and subordinate marls and shales. The total thickness ranges from 800 m to 2,500 meters, increasing and dipping towards the Gulf.


0 20 40
Kilometers
Tarut
Al Qatif
Ad Dammam
Al Khobar
Al Manamah
Buqayq
Al Hufuf
Date Palm Oasis
Sabkha
Historical Onshore Spring
Historical Offshore Spring


Elevation (meters)
500
0
-500
-1000
0
50
100
Kilometer
Arabian Gulf

Bahrain's submarine spring discharge isn't much -- 9 liters/second, the only estimate -- and has diminished since the 1980s. Salinity is one-tenth that of seawater.

Down Under

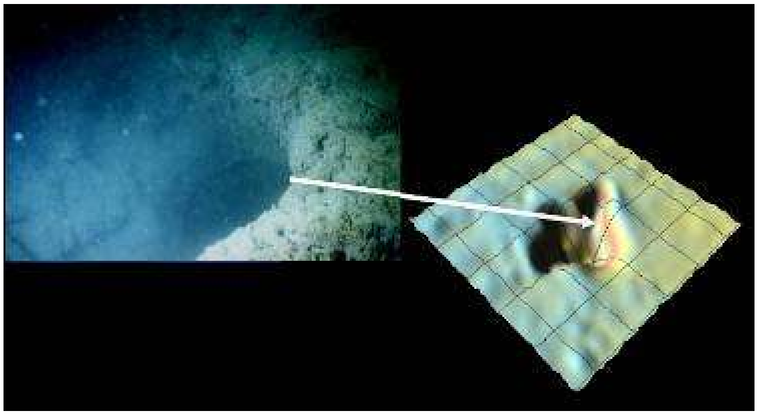
For the rest of us, underground springs feed rivers, but on continent of Kircherian oddities, submarine rivers feed springs.

A "wonky hole," the Australian term for a freshwater spring on the seabed, are freshwater springs of up to 30 meters in diameter and 4 meters deep in the coral reef. Approximately 200 have been identified, some as far as 10 kilometers offshore.

Wonky holes are the termini of paleochannels of ice-age riverbeds. The alluvium, since submerged by sea rise and more permeable than the sea deposits that blanket it, conveys terrestrial fresh water to thin spots in its coral covering.

Queensland fishermen coined the term "wonky holes" because the rough seabed around the springs can snag nets and overturn craft.

The photograph and acoustical map of a wonky hole is from "Acoustic Seafloor Mapping in the Great Barrier Reef," a 2004 report of fieldwork by Thomas Stieglitz.



"On Some Repairs to the South American Company's Cable off Cape Verde in 1893 and 1895," Electrician, April 2, 1897, by Henry Benest,

> *It is said that many rivers in Australia run underground, and in a paper read in July last year before the Queensland Royal Society by Mr. R.L. Jack, the Government Geologist, dealing with the question of submarine leakage of artesian water in Australia.*
>
> *The outflow on the land is not sufficient to account for the loss. The rocks, it is concluded, must outcrop somewhere below sea level, and the constant pressure of water from the head sources on land results in a steady outflow of fresh water at this lower level.*
>
> *Far out in the Gulf of Carpentaria, beyond the influence of flood waters from rivers that run into the gulf, fresh water, it is said, can be drawn up in a bucket. Rocks at a depth of over 600 meters, close to the edge of the gulf, contain artesian water.*
>
> *Off the Victorian coast, it has been said fresh water may be obtained from a so-called spring out at sea. In such these cases it seems very probable that a portion of the great quantity of water absorbed by the porous strata may eventually find its way out beneath sea level.*

Wonky holes may be the basis for A.N. Semikhatov's remark in Hydrogeloegy (1954) that in the Gulf of Carpentaria, locals use long bamboo stems to obtain fresh water from submarine springs.

Croatia

Submarine spring near Doli

Commercial Application

The company Nymphea/Geocean has experimented with capture of fresh water from a 36-meter deep submarine spring in well-developed karst approximately 1 kilometer offshore near the French/Italian border.

Technical development and pursuit of commercial applications are ongoing.

We'll investigate several purported cases of submarine-spring havoc in Chapter 70, On Some Repairs to the South American Company's Cable.

Submarine Rivers

The term "submarine river," as commonly employed, does not imply a closed conduit. A "submarine river" is more commonly viewed to be a channelized flow winding its way down trench the sea bed.

Gravity holds an earth-surface river within the lowest channel geometry for a given area. Two square meters of fluid cross-section assume the lowest 2 square meters of channel geometry.

In an ocean-bottom trough, on the other hand, only a liquid more dense than the ocean above will remain within the depression. As cold water is denser than warm water (other than at just above freezing conditions, all else being equal) a stream of colder water will hug the sea floor until the thermal gradient dissipates. A slurry of particulates will likewise flow along the sea bed until turbulence disperses the load. As salt water is denser than fresh water, the same applies to seawater introduced beneath fresh water.

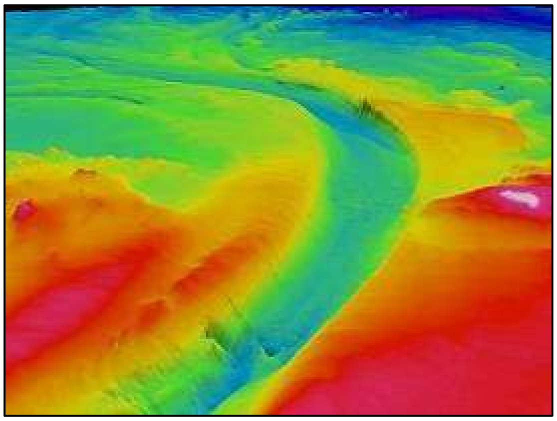
Because it's less saline, however, submarine spring water is less dense than the seawater into which it emerges and thus will rise. A submarine spring does become a submarine river.

But there are indeed submarine rivers, open channels of dense liquid flowing in riverine manner along submarine depressions.

Three conditions must be satisfied for submarine riverine flow:

1. A fluid denser than that above. A special case of this condition is that of turbidity currents, submarine discharges significantly heavier than saltwater due to hyper-concentrated suspended load. Turbidity currents occur when masses of sediment accumulated on the lip of an oceanic shelf careen down the slope in landslide-like manner. The trigger mechanism may be the mass' own weight or a seismic vibration. The terrestrial equivalent would be a "debris flow," the bane of Southern California homes constructed on steep slopes in times of torrential downpour. As we will see in Chapter 70, turbidity currents can be rapid and extensive, devastating the seabed in its path.
2, Lateral confinement. Without this, it's a submarine lake, water permanently trapped in the depths of a sea-floor depression. Such water generally turns anaerobic.
3. A downstream energy gradient. As with a river of any sort, there must be an upstream-downstream elevation differential to propel the discharge.

For an example, let us go to Istanbul. As documented by Ferdinando Marsigli's Observations around the Bosporus Strait or True Canal of Constantinople (1681), flow into the Mediterranean through the Bosporus Strait is long known to occur in strata. It wasn't until 2010, however, that a robotic submarine mapped how the strait's current's eroded the sea-bed channel.



The submarine channel is up to 35 meters deep and 1 kilometer wide and persists for 60 kilometers. Its 6-kilometer/hour velocity exceeds that of many major terrestrial rivers. Discharge is 22,000 cubic meters/second, 10 times that of the Rhine.

Sonar scans reveal meandering channels up to 4,000 kilometers in length and several kilometers wide in many of the world's oceans, most having been formed when sea levels were lower. The Bosporus channel, small in comparison, is the only one known to still be actively scouring

Like terrestrial meandering channels, sediment scoured from the bed is deposited at the edges. The Bosporus submarine river has tributaries, flood plains, rapids and even waterfalls. According to research leader Dan Parsons,

> *It flows down the sea shelf and out into the abyssal plain much like a river on land. The abyssal plains of our oceans are like the deserts of the marine world, but these channels can deliver nutrients and ingredients needed for life out over these deserts.*
>
> *This means they could be vitally important, like arteries providing life to the deep ocean.*

While Parsons isn't making analogy to the arterial theory of springflow (Chapter 8), his alimentary allusion illustrates how we still turn to our own physiology to explain the harder-to-see parts of nature.

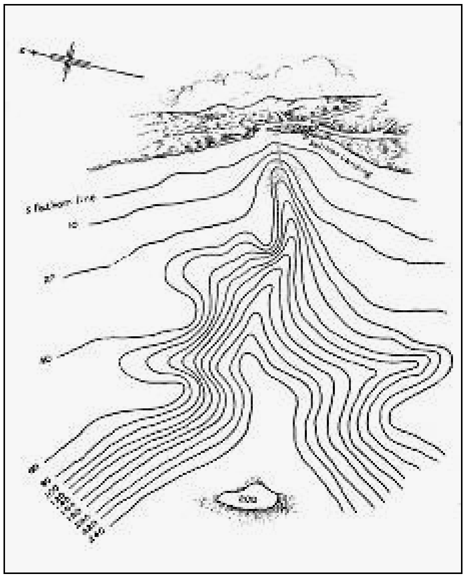
The conditions for the existence of a submarine river are satisfied.

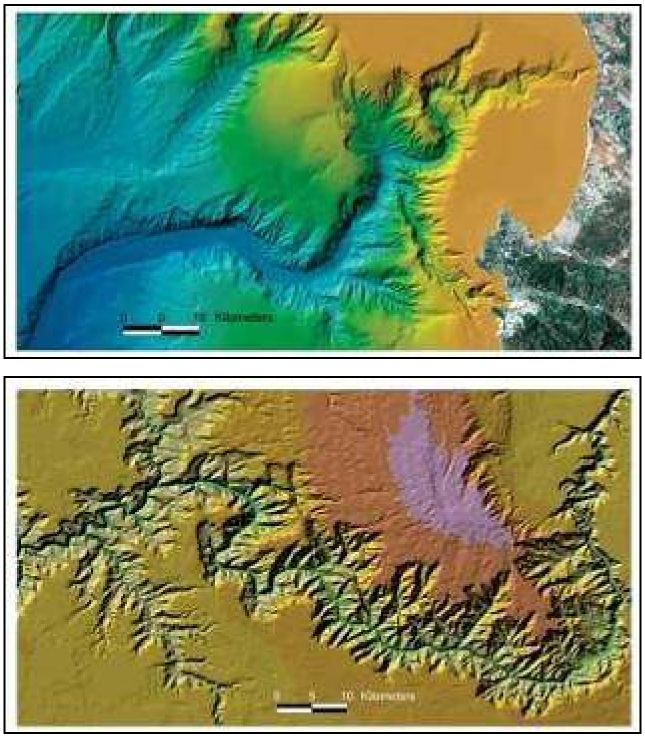
1. A fluid denser than that above. The Bosporus underflow bears sediment (though not enough to make it a full-fledged turbidity current) and is both more saline and relatively colder than the tidal water above. The net sediment flux into the Black Sea contributes to anoxic conditions within that waterbody.
2. Lateral confinement. The Straits were eroded by a rising Mediterranean sea level breaching into the originally-lower Black Sea. Today, tidal flux scours deposition from the incised submarine streambed while aggradation augments the submarine stream bank, much as floodwaters behave on a flood plain.
3. An energy gradient. The tidal difference between the Mediterranean and Black Seas is the engine.

For an example pertaining to the second condition, we can go to ancient California when the Sacramento River flowed to Monterey Bay until the outlet was blocked, transforming the Central Valley into an inland sea 800 kilometers long and more than 300 meters deep. About 650,000 years ago, the lake catastrophically overflowed to its current outlet, San Francisco Bay.

Long-since inundated by sea level rise, the abandoned Monterey canyon of today extends some 200 kilometers into the Pacific, reaching depths of up to 3.6 kilometers below sea level. The canyon is half that deep.

The sounding of the Monterey Bay, below left, is from "Submarine Gullies, River Outlets, and Fresh-Water Escapes Beneath the Sea-Level," Geographical Journal, October 1899, the discussion of which we will pursue in Chapter 70.





In the top-right is the morphology of the submarine canyon. The bottom-right is that of the Grand Canyon at the same scale.

In Chapter 86, The Rio San Buenaventura, we will consider the hypothesis that the Great Salt Lake of Utah yet discharges to Monterey Bay via a subterranean reach of the elusive Rio San Buenaventura. Were this the case, the salt-laden submarine outflow indeed might glide down the sub-Pacific trench, at least for a ways. As for the validity of the hypothesis, however, we must wait until that chapter.

Submarine rivers aren't subterranean rivers, per se, we realize, but it wasn't a long digression.

CHAPTER 43

THE HYDRAULICS OF UNDERGROUND WATERS

Understanding subterranean waterbodies rests on an understanding of water on the surface. It may be darker down there, but water doesn't require illumination to behave like water. We don't need a fantastic science; the cave tour guide may show us a "bottomless pit," but we're confident that there's a bottom. We could strike "underground" from the title of this chapter without negating the contents.

The term "hydrology" encompasses many facets of water science. The term "hydraulics" pertains to fluid mechanics. We touched on Darcy's Law, a hydraulic topic, in Chapter 38, Hydrogeology, because groundwater science wouldn't be science without Darcy, but we didn't explain the law itself. We talked about larger subterranean conduits in Chapters 39, but didn't pursue the underlying mechanics.

In this chapter we must be a bit mathematical.

Paolo Frisi (1728-1784) contributed to mathematics, physics and astronomy, but unfortunately his physics was based on vibrations in the ether. His major work on hydraulics was Treatise on Rivers and Torrents (1762). An engineer with little confidence in the application of mathematics to problems o fluid mechanics, Frisi saw scant hope for numerical solutions.

> *One single reflection is sufficient to show that all hydraulic problems are beyond the reach of geometry and calculus. The difficulty of all problems is increased in proportion to the number of conditions [variables]... In a fluid mass which moves in a tube or in a canal, the number of bodies is infinite; whence it follows that to determine the motion of each body is a problem depending on an infinity of equations, which is, of course, beyond the powers of algebra to reach.*

Things turned out not quite that bad, however, and as with all physical sciences, mathematics came to be a fundamental tool of analysis. We needn't track every part to predict the behavior of the whole.

More ever, again as in all of science, seemingly diverse manifestations often share common physical bases, and in understanding one, we may thus better understand the others. As noted in the sage advice passed on by H.M. Birdwood in "The Recent Epidemics of Plague in Bombay," Journal of the Manchester Geographical Society (1897),

> *In his report on the sanitation of Bombay, Mr. Baldwin Latham observes that underground water obeys exactly the same law as water flowing on the surface of land.*

We're simply applying conventional physical principles of fluid mechanics to a particular environment.

The Darcy-Weisbach Equation

The Darcy-Weisbach equation (developed by Henry Darcy and refined by Julius Weisbach) states that,

$$V = \sqrt{\frac{Rg}{8f}\frac{H}{L}}$$

where

V is the fluid velocity,

R is the hydraulic radius, the cross-sectional area/wetted perimeter, $d/4$ for a circular conduit

d is conduit diameter,

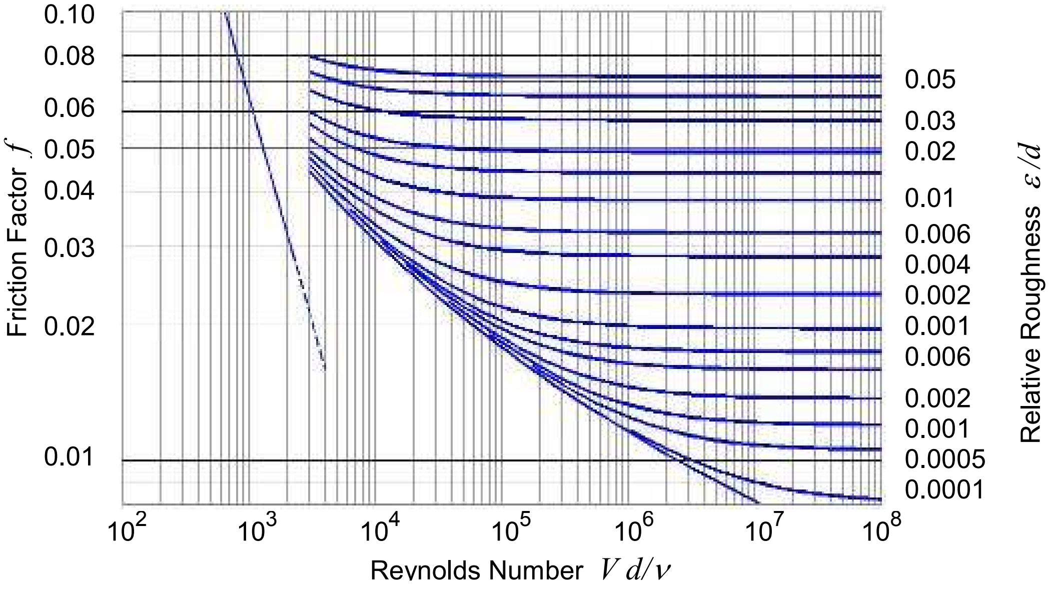
g is the gravitational constant,

f is a friction factor,

H is the pressure head and/or elevation loss, and

L is the conduit length

The chart below, the Moody Diagram, shows the dependence of the friction factor f on other factors.



where ν is kinematic viscosity, and

ε is the dimensions of the roughness elements. ε for concrete ranges from 0.3 to 5 millimeters. For granular materials, ε is generally taken to be the sieve size through which 84 percent of the particles pass.

We note three regions in the Moody Diagram.

1. The straight line to the left describes "laminar flow." The fluid mass moves with minimal lateral exchange of fluid particles. . A dye-trace caries downstream as a ribbon.

   As a rough rule, water in a circular conduit is laminar if $Vd < 0.002$ square meters/second. Water flowing at 1 meter/minute in a 1-centimeter tube is laminar ($Vd = 0.00017$ square meters/second).

2. A transitional middle portion.
3. A family of horizontal lines to the right representing "fully turbulent flow." Fluid particles continually exchange position with their neighbors. A drop of dye promptly disperses across the cross-section. If the velocity in the 1-centimeter tube is 1 meter/second, the flow is turbulent ($Vd = 0.01$ square meters/second).

The Darcy-Weisbach Equation and the Moody Diagram are sufficient to estimate flow velocities for any pipe of any diameter, length, head and material, but the mathematics can require iteration. For most applications, we'd prefer a formula a bit simpler.

Darcy's Law

The Moody diagram shows that under laminar conditions, f depends only upon fluid velocity, fluid viscosity and conduit dimension, but not on the roughness elements. Viscosity is sufficient for adjacent fluid particles to blanket the roughness. The remainder of the fluid is slowed by the drag of the stuck fluid particles, not the surface itself.

For flow in porous media, Darcy's Law approximates the left-hand portion of the Moody diagram allowing a simpler computation based on an empirical K.

Based on sand filter experiments for the City of Dijon water supply, civil engineer Henry Darcy (the same Darcy, in fact) was the first to determine the energy-based law governing fluid flow through porous media. From his report, Les Fontaines Publiques de la Ville de Dijon (1856),

> *I approach now an account of the experiments that I carried out at Dijon together with Engineer Charles Ritter, to determine the laws of flow of water through sand. Each experiment consisted of establishing a specified pressure in the upper chamber of the column by adjustment of the inflow tap; then when it was established by means of two observations that the flow had become essentially uniform, the outflow from the filter during a certain time was noted, and the mean outflow per minute was calculated from it.*

The velocity of water through porous media is product of the energy gradient and a coefficient representing the nature of the media.

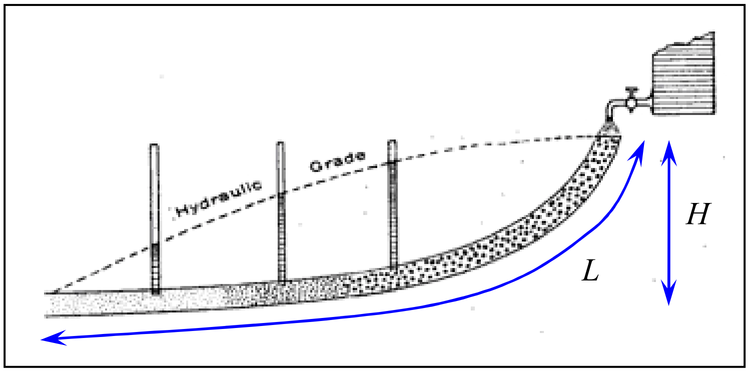
$$V_{Darcy} = K \, {}^{H}\!/_{L}$$

where V_{Darcy} is the velocity as if the subsurface pathway were fully open,
K is a conductivity parameter related to the media. The larger the interstices, the larger the K,

The H term is often called "head loss." Report of the Geological Survey of New South Wales Mineral Resources (1901) provides an early description of the experimental basis.

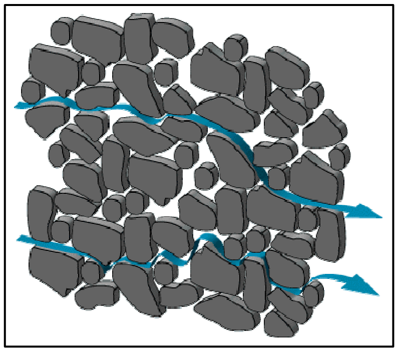
> *The pipe was filled with sand, coarse shot, and marbles in consecutive order, to represent beds of decreasing porosity. Three vertical glass tubes were luted into holes in the lead pipe, tapping respectively the parts of the pipe filled with sand, shot and marbles. The lower end of the pipe was loosely stopped with a brick to keep the materials in their places. Water was then poured into the upper end of the pipe until the latter was filled, and as the water escaped through the lower end more was poured in to keep the pipe full. The water ascended the three vertical glass tubes, and remained stationary at a certain height in each.*

Laboratory estimation of a material's conductivity K is simple. Fill a pipe of length L with the porous media. Raise one end H and observe how much discharge can be transmitted. Divide that discharge by the pipe cross-section to find V_{Darcy} and solve Darcy's Law for K.



The curvature of the illustrated hydraulic grade line implies that the pipe contains continuously-graded material, beginning with marbles and gradually changing to sand. Were the material in three distinct segments -- as the report seems to suggest -- the hydraulic grade line would appear as three straight lines: flat, mild and steep.

The physical path of a parcel of water through a maze of pores is convoluted, of course, but such non idealities are incorporated into the formula's empirical K.



As the subsurface pathway is partially blocked by solid particles, the actual groundwater velocity is,

$$V = {}^{V_{Darcy}}\!\big/_{\phi}$$

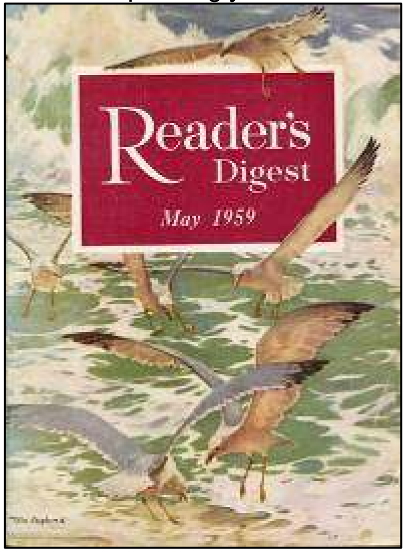
where ϕ is the media's porosity, the volume of voids per unit volume of soil.

Tabulated below are V values for H/L = 0.001, a typical energy gradient.

	Typical K (m/s)	V_{Darcy} (m/s)	Typical ϕ	Typical units of V
Unconsolidated Sediment				
Gravel	0.7	0.0007	0.25	m/hour
Coarse Sand	0.06	0.00006	0.30	m/day
Medium Sand	0.006	0.000006	0.20	m/day
Fine Sand	0.002	0.000002	0.20	m/month
Silt, Loess	0.00004	0.00000004	0.15	m/year
Till	0.0000004	0.0000000004	0.20	m/century
Clay	0.00000006	0.00000000006	0.25	m/millennium
Unweathered Marine Clay	0.00000001	0.00000000001	0.30	m/millennium
Sedimentary Rock				
Limestone, Dolomite	0.00002	0.00000002	0.15	m/year
Sandstone	0.00001	0.00000001	0.20	m/year
Siltstone	0.0000001	0.0000000001	0.25	m/century
Shale	0.000000004	0.000000000004	0.05	m/millennium
Crystalline Rock				
Permeable Basalt	0.02	0.00002	0.25	m/day
Fractured Rock	0.0004	0.0000004	0.05	m/month
Weathered Granite	0.003	0.000003	0.03	m/day
Basalt	0.0000007	0.0000000007	0.02	m/year
Unfractured Rock	0.0000000009	0.0000000000009	0.01	m/millennium

The table doesn't show the large range of values within a particular soil category, nor does it indicate the nature of mixed soils. In general, when a coarse-grained material is mixed with one of finer grains, it's the latter that controls the passage of water. According to the table, velocities through gravel may be the meter/hour range, but that's for clean, uniform stone. Buried gravel is generally packed with sands, silts and clays and the transmission is correspondingly reduced.

Regarding the benefits of atomic explosions, Edward Teller, father of the hydrogen bomb, informed the readers of Reader's Digest, May 1959, "How Nuclear Blasts Can Be Used for Peace."



> *We can control underground rivers and conserve water. Many of the world's rivers flow uselessly through desert regions on beds of water-impervious rock. We could set off nuclear explosions beneath this bedrock so that water could seep through the rubble and the earth's strata, thus raising the water table to the point where irrigation would be easy.*

Dr. Teller's slution is just increasing the permeability.

THE...INVENTIVENESS OF MAN SHALL...BE...
CONSECRATED TO HIS LIFE
TO FIND THE WAY BY WHICH
ATOMS FOR PEACE
3¢ UNITED STATES POSTAGE 3¢

If this is just too much math, the Christian Science Monitor, June 14, 1913, got it about right with the headline, "Underground River Waters Found to Flow Mile a Year."

Manning's Equation

The right-hand side of the Moody Diagram shows that for fully turbulent flow, the roughness f depends only on the conduit dimension and the height of the roughness elements... The larger the elements, the greater the drag. Viscosity is no longer a factor.

Under such conditions, the Manning's equation applies,

$$V = \frac{R^{2/3} S^{1/2}}{n}$$

where S is the slope of the energy gradient H/L, and
n is a Manning friction factor, typical values shown below.

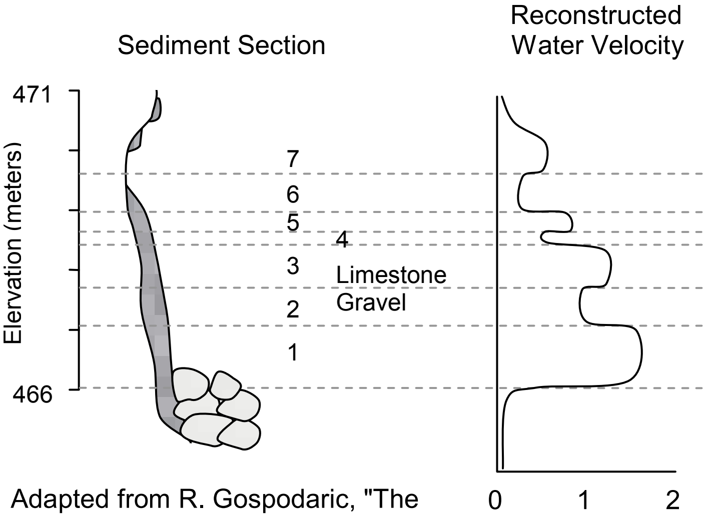
Material	Roughness n	
Rock	0.025-0.030	Smooth
	0.036-0.045	Unshaped, jagged, irregular surfaces
Sand	0.026-0.035	
Gravel	0.028-0.035	
Cobble	0.030-0.050	
Boulder	0.040-0.070	
Adjustment for Variation in Cross Section		
Alternating occasionally	0.001-0.005	
Alternating frequently	0.010-0.015	
Adjustment for Obstructions		
Negligible	0.000-0.004	< 5 percent of cross-section
Minor	0.005-0.015	5-15 percent of cross-section. Influence of one obstruction does not affect influence of another obstruction.
Appreciable	0.020-0.030	15-50 percent of cross-section. Effects of several obstructions are additive
Severe	0.040-0.050	>50 percent of cross-section

For a slightly-sloped karst conduit having diameters measured in centimeters, velocity may be in the range of meters/minute, not the speed of a freely-flowing river, but orders of magnitude faster than groundwater flowing through porous earth. Flow in karst aquifers is usually in the turbulent regime.

Sediment Deposition

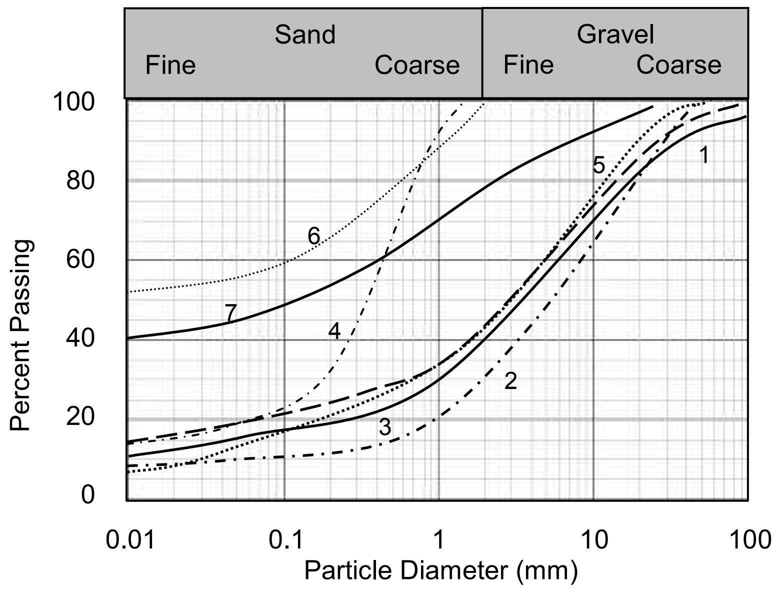
Hydraulic inferences can be drawn from drained conduits, but as reflected by **Stein-Erik Lauritzen**, University of Bergen in 1985, the study of fossil conduits "is a direst parallel to the case of medieval anatomists dissecting a dead body rather than studying the physiology of the living organism."

With that cautionary note in mind, let us look at a study in which the gradations of fluvial strata within a cave were appraised for the flow velocity likely to have deposited them. The case is that of a Slovenian cave into which flows the Rak River, a watercourse we will again visit in Chapter 72, Underground and Balkanized


Sediment Section
Reconstructed Water Velocity
471
466
Elevation (meters)
7
6
5
4
3
2
1
Limestone Gravel
0
1
2
Velocity (meters/second)

Adapted from R. Gospodaric, "The Quarterary Caves Development between the Pivka Basin and the Polje of Planina," Acta Carsologica 7, 1976

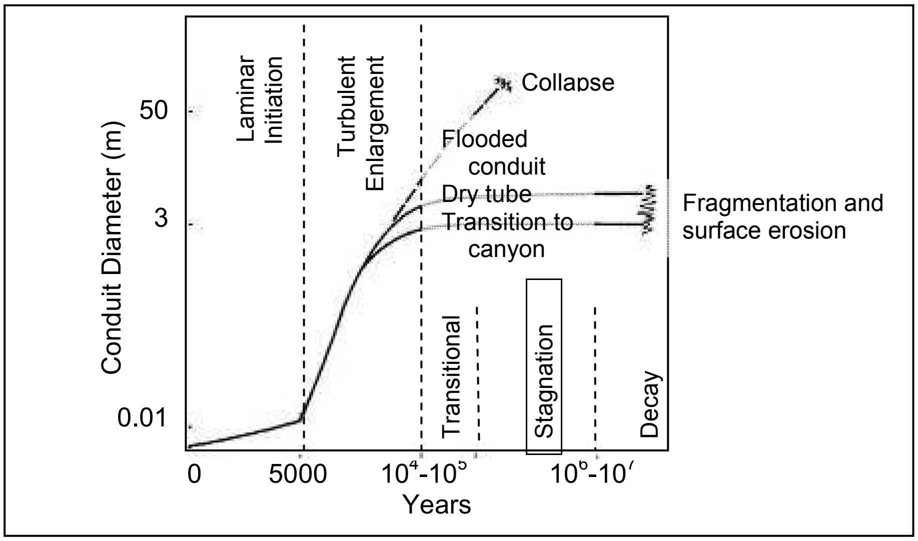
The cave walls indicate layers of deposits, gradations shown below. Strata 1, 2, 3, 5 and 5 contain a significant portion of coarse gravel. Strata 4 and 6 are entirely sand. The velocity estimations are derived from sediment-transport theory. The values, some exceeding 1 meter/second, are high for cave channels, but as will be noted in Chapter 72, the Rak River is exceptionally rapid.



As can be seen from the velocity estimations, strata 2, 4 and 6 were probably deposited by slower waters. Such back-calculated velocities, as Lauritzen would warn, incorporate a spectrum of simplifying assumptions, but the qualitative conclusion is probably reasonable.

Conduit Diameters

Karst passages are nonstationary in a geologic sense, which is to say that conduit dimensions, and thus capacity, change. The graph below illustrates the growth.



In the order of 5000 years are required for karst chemistry to enlarge a passageway to 1 centimeter in diameter. At about this dimension, the flow regime switches from a laminar to turbulent regime and the flow is able to transport fine insoluble particles, accelerating the subsequent rate of enlargement. Infiltration from a 1 square-kilometer watershed can enlarge a cavern to several meters in diameter in another 10,000 to 100,000 years.

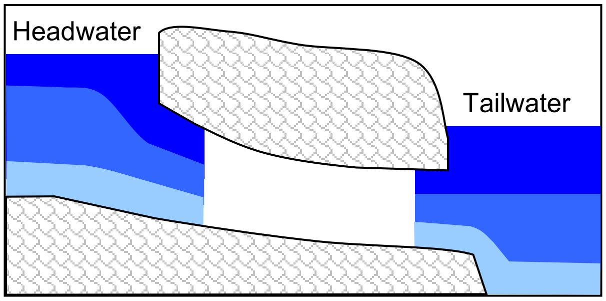
If the cavern's water level lowers, canyons may develop in the floor. Dry tubes may persist until the unsupported passages fragment or are removed by erosion. A continuously-flooded cave can grow to a diameter in the 50-meter range, but eventually the roof will collapse.

All this is to say that where we speak of conduit dimensions in the paragraphs to follow, we're talking about a parameter that may change over time.

Connecting Conduits

An additional class of hydraulic analyses merits mention -- computations an engineer would recognize as "culvert hydraulics."

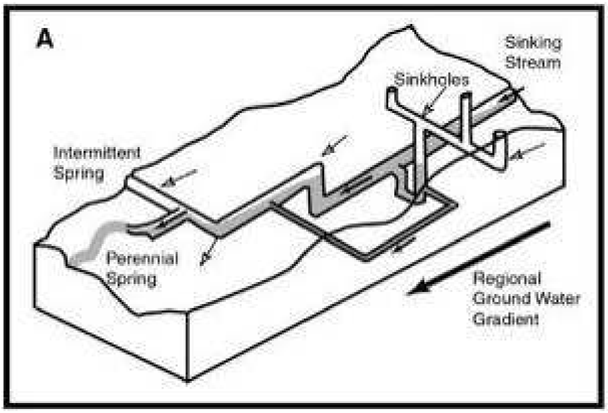
Hydraulic behavior involved when a river runs into the ground and emerges downstream varies according to the "boundary conditions." Headwater may be high enough to cover the inlet (which sometimes creates a vortex), may be such that flows draws down to enter or may be low enough that the flow doesn't even recognize that it's entered a cave. Tailwater may likewise be high enough to submerge the outlet, be at an elevation that backs water into the cave's lower reaches or be so low that the outflow behaves as a waterfall.



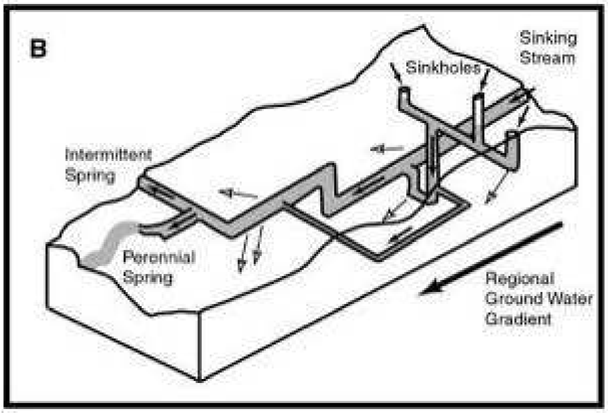
Flow within the connecting cavern may fill the conduit -- and thus be pressurized -- or flow with a free surface or flow as a combination, full in some places, partially full in others. Depending on head and tailwater elevations, conduit length, cross-sectional and transition geometries and surface roughness, all combinations of inlet, conduit and outlet hydraulics are possible.

The cases are few when a natural underground river flows into, through and then out of a cave -- we will note a Laotian instance in Chapter 51, The Tourist Trade Worldwide-- but fictional underground rivers often do so, as illustrated in Chapters 16-25. A favorite combination for a good story involves an upstream whirlpool, a dashing rapid ride through the cave -- the riders need the air, after all -- and a graceful exit into a downstream wonderland.

Exchange of Matrix and Conduit Water with Examples from the Floridan Aquifer, USGS Water-Resources Investigations Report 01-4011 (2001) by Jonathan B. Martin and Elizabeth J. Screaton diagrams the possible distribution of conduits in a karst region.



Normal conditions when water enters conduits from matrix porosity and fractures. Some conduits may be only partially filled. Open arrows reflect flow from matrix to conduits except at constrictions where flow may be from conduit to matrix.



Flood conditions when all conduits are filled from recharge. If head is sufficient, water flows from conduits to matrix, the flow path represented by open arrows. Such water might become entrained in regional groundwater flow.

Modeling

Hydraulic modeling is the analytic endeavor, generally assisted by computer, by which a complex natural system is decomposed into components which can be physically understood and then those parts are reassembled in interactive relationships. Most studies link together a set of sub-models, e.g., one related to meteorology, another related to land use, another related to streamflow and another related to groundwater

We'll simply take a look at how one particular sub-model, the modular finite-difference groundwater flow model MODFLOW, handles subsurface conduits.

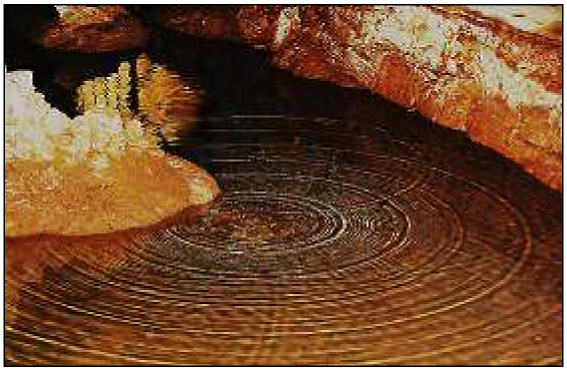
MODFLOW's conduit flow process (CFP) can estimate subsurface flow through carbonate aquifers, voids in fractured rock, and/or lava tubes and can deal with fully or partially saturated flow under laminar or turbulent flow conditions, which is to say that once the physical processes are identified, the computer can handle the math. What we might be call an "underground river" most certainly isn't a prismatic pipe buried within the earth, but in terms of behavior, there is some hypothetical piping scheme that transports water in an equivalent manner.

CFP data may include conduit pipe locations, lengths, diameters, tortuosity, internal roughness and critical Reynolds number to determine if flow is laminar or turbulent. As with many hydrologic computer models, however, the user need not know the value of all parameters a priory. Rather, he or she uses field data of observed behavior to back-calculate the unknown values.

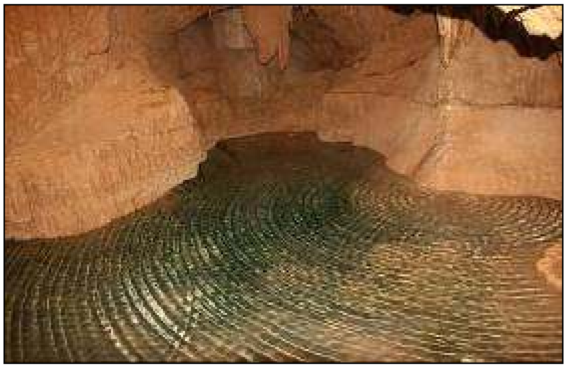
Ripples

The water in most karst systems -- we should remind ourselves -- moves at almost imperceptible velocity. No wind ruffles the surface. No cobble rolls from the bank. Nature, if we may say so, is better behaved than it is above.

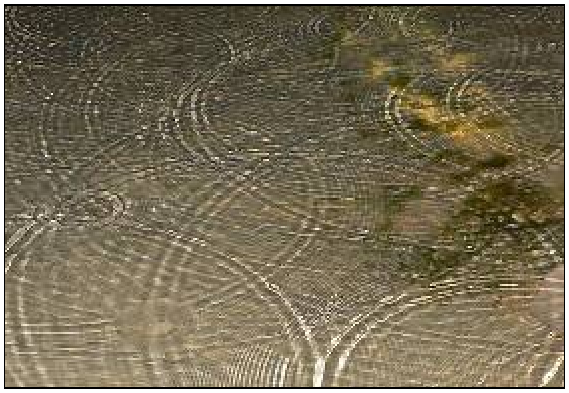
In such quiescence, nature is precise. Take, for example, the intersecting ripples diverging in seemingly-flawless regularity on the surface of an underground pool.



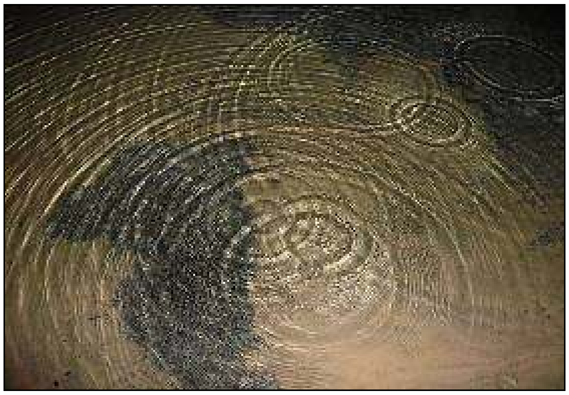
Yarrangobilly Caves, Australia



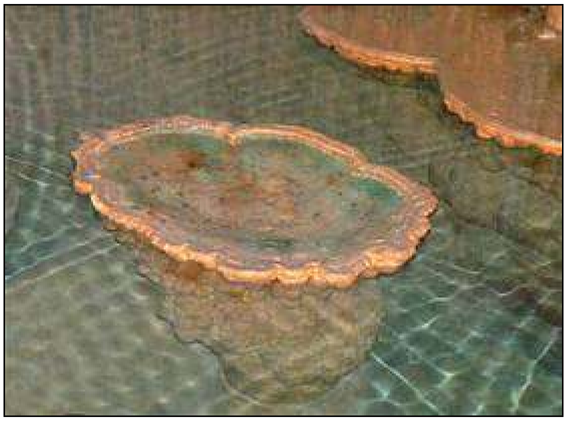
Subterranean River Midro'i, France



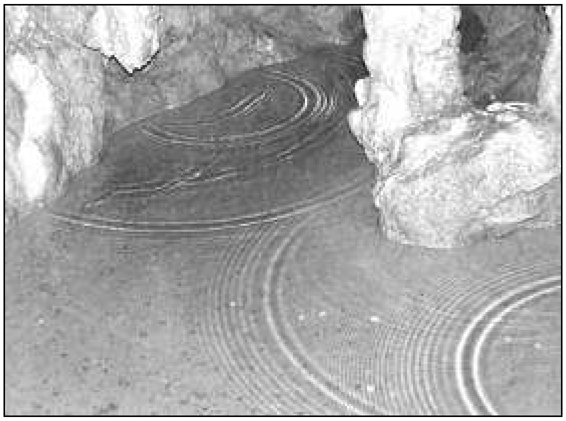
Harrison's Cave, Barbados



Merry Branch Cave, Tennessee



Onondaga Cave, Missouri (Chapter 52)



Woodward Cave, Pennsylvania

Do our eyes deceive us, or are we seeing the same thing?

Ripples occur when a point on the water surface is displaced from its equilibrium elevation. The fluid exerts a reaction, trying to regain its original level. When it does, however, its momentum causes it to overshoot, leading to an oscillation.

The back-and-forth exchange of potential and kinetic energy causes adjacent fluid particles to rise and fall and energy is radially transferred until viscosity causes the wave to decrease in amplitude. The particles themselves don't travel with the wave form; they just bob in the same place.

Two forces govern the water surface's restorative reaction: the force of gravity and the force of surface tension. Ripples occur when the dispersion caused by gravity cancels out the dispersion due to surface tension, or to put it in other terms, when gravity waves and capillary waves act as one.

A ripple's wavelength (crest to crest) λ is a function of the fluid's surface tension.

$$\lambda = 2\pi\sqrt{\frac{\sigma}{(\rho - \rho')g}}$$

where σ is the surface tension of the fluid
ρ is the density of the fluid
ρ' is the density of air and
g is gravity

For an air-water interface, λ is 1.7 centimeters.

Waves with wavelengths much smaller than this are dominated by surface tension. They travel slower than the wave group as a whole and they die out as they're left behind the group's trailing boundary. Waves with wavelengths much longer than this are dominated by gravity. They travel faster than the group as a whole, but they die out as they approach the leading edge.

The velocity c for a gravity-capillary wave is,

$$c = \sqrt{\frac{g\lambda}{2\pi} + \frac{2\pi\sigma}{\rho\lambda}}$$

The ripple's velocity is 23 centimeters/second, and as the dispersions cancel, the wave from can travel for long distances.

The forces increase in complexity if the wave height is significant in comparison to the water depth or if the initial intrusion is that of a large object, but the math we've presented does reasonably well in describing the wave patterns illustrated at the beginning of this section.

Our eyes were not deceiving us. The photos are essentially the same. Had we compared videos, the motion would have been much the same. Ripples in otherwise-quiescent cave waters are spaced at about 2 centimeters and radiate at about 20 centimeters/second.

Conclusion

We could incorporate any number of further hydraulic topics to our study; an underground river is, after all, subject to the same rules as are waters above. But we'll stop with a few computations pertaining to fluid behaviors that might catch the attention of a cave visitor.

Fluid mechanics can be analytically complex, but we've the practical advantage of day-to-day observation in our own world. Rivers underground are darker, or course, but the water's the same.

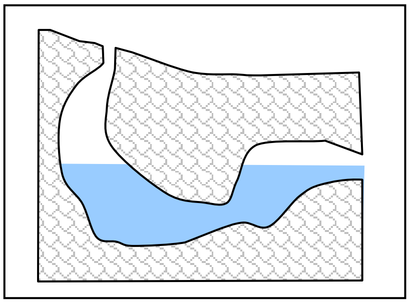
CHAPTER 44
SIPHONS

As applied to flow through a closed conduit, a "siphon" can refer to one of two flow paths:

> One which the flow dips beneath a barrier lower than both the inlet and outlet water surfaces. This down-and-up pathway is properly called an "inverted siphon."
>
> One in which the flow is first drawn above the inlet water surface and then descends, an up-and-down pathway.

Inverted Siphons

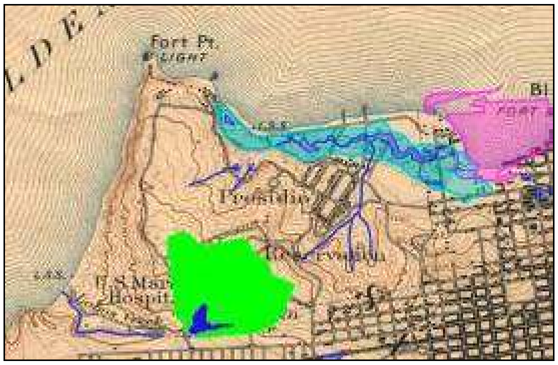
Spelunking and geologic literature frequently omits the adjective "inverted" in reference to inverted siphons. We must simply be aware that scuba divers, for example, who negotiate "siphons" are simply swimming beneath an obstruction in their passage, as opposed to being sucked up and over a crest, as would a true siphon.



In what promises to be a lengthy tome, The Annals of San Francisco; Containing a Summary of the History of .the Discovery, Settlement, Progress, and Present Condition of California and a Complete History of All the Important Events Connected with its Great City (1855), Frank Soulé describes San Francisco's potential water supply.

> *In a place like San Francisco, so much exposed from position and circumstance to conflagration, the unlimited supply of water for extinguishing fires is particularly requisite; and that will surely be obtained when this company has completed its works. Its name is taken from the Mountain Lake, which is but a small sheet of water, and of itself could not yield the expected supplies. This lake has no visible outlet. A few hundred yards from its northern margin, there gushes through the ground a full stream or water, which is believed to be amply sufficient for all the purposes of a city thrice the size of San Francisco. It is matter of doubt whether this great spring, or rather subterranean river, is the vent of the small Mountain Lake, or whether it is not the open end of a natural siphon, which discharges the rains and dews that fall among the mountains on the opposite shores of the bay.*

The final line confirms that the author envisions not a true siphon passing over coastal mountains, but rather an inverted siphon dipping under the San Francisco Bay. From the map of Mountain Lake and its watershed, we can appreciate the author's doubt that such a reservoir could result from so small a watershed. The underestimation's a familiar one in the history of hydrology.



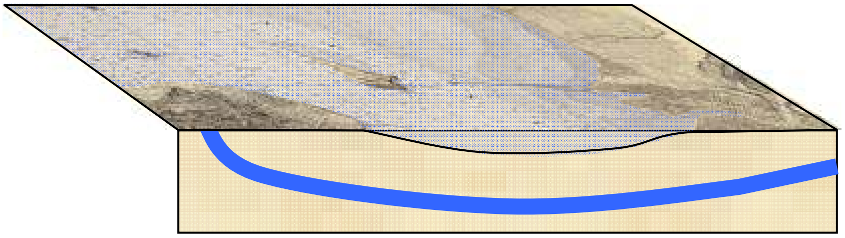
Topographic map from the 1890s

Mountain Lake, 1890

The English Mechanic and World of Science, April 4, 1879, differed in the city of comparison.

> *Engineers are confident, it is said, that the subterranean river flowing under San Francisco, leading direct from the exhaustless lakes of the Sierra Nevada, is quite adequate to supply several cities of the size of Baltimore.*

Baltimore numbered more than 330,000. At 200 liter/capita/day, such a sub-Bay siphon would need to convey 2 cubic meters/second. Taking Lake Tahoe as the "exhaustless lakes of the Sierra Nevada" to estimate grade, a 2-meter stone conduit could transmit that flow, not out of scale with the modern city's water system. Given Soulé's concern for an "unlimited supply for water for extinguishing fires," such an inverted siphon would have been fortuitous in 1906.



Inverted Siphon, 1859 Map of San Francisco Bay

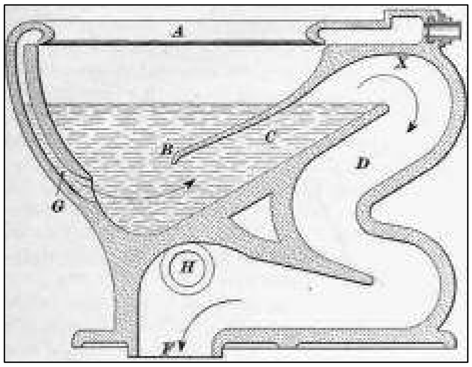
True Siphons

A true siphon involves the suction of water up and over a crest higher than the reservoir from which the flow is drawn.

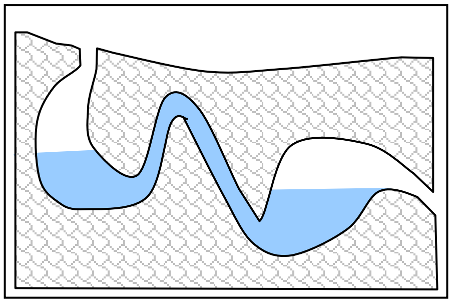
Illustration from Common Science (1921)
by Carleton Washburne

We're more than familiar with the concept. From "Water Closets" from A Treatise on Architecture and Building Construction (1899) by Colliery Engineer Co.,

> *The contents of the bowl are sucked out by the siphon, which is formed by the two tubes C and D. Some of the water which enters the flushing rim A rushes down the tube G, forming a strong jet, which drives the water in C up into the space X and fills the tube D. As D is longer than C, the two act as a siphon until the water in the bowl falls below the lip B.*



For a siphon to function, certain criteria must be satisfied:



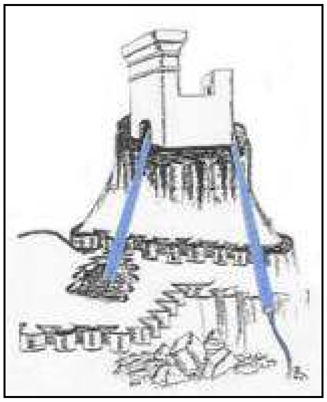
Water can not be drawn more than roughly 10 meters above the surface of the inlet reservoir.

The outlet reservoir, it there is one, or otherwise the outlet itself, must be lower than the inlet reservoir.

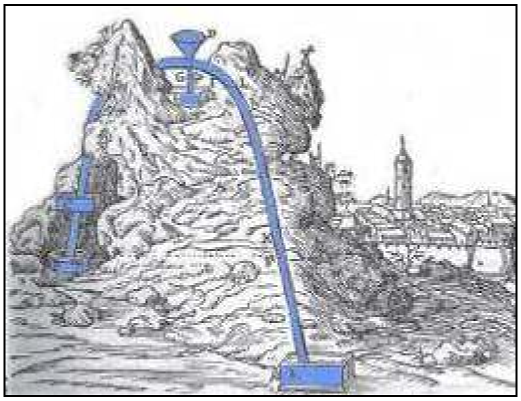
The conduit can not be opened the atmosphere at any point higher than the inlet reservoir or air will enter and break the siphon. Thus, the inlet orifice must be entirely submerged.

The siphon must be primed, i.e., the conduit must be filled at all points above the inlet water surface.

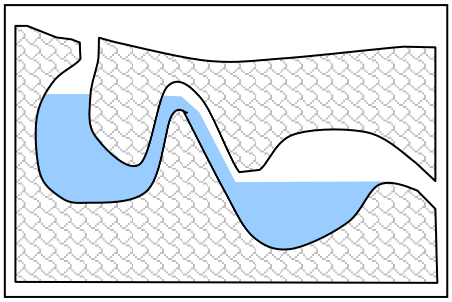
Priming can be achieved by filling the conduit from either end, but as nature offers no suitable pump, a natural siphon primes when the elevation of the upstream reservoir exceeds that of the soffit (the highest point in a cross-section) at the crest and the flow fills the cross-section.



The 15th-century scheme for siphoning water to a castle appears to violate the 10-meter criteria. Opening the pipe in the castle to serve its purpose allows atmospheric intrusion.



Gaspar Schott included a similar siphon in Mechanica Hydraulico-Pneumatica (1657). The funnel-like apparatus is for priming.

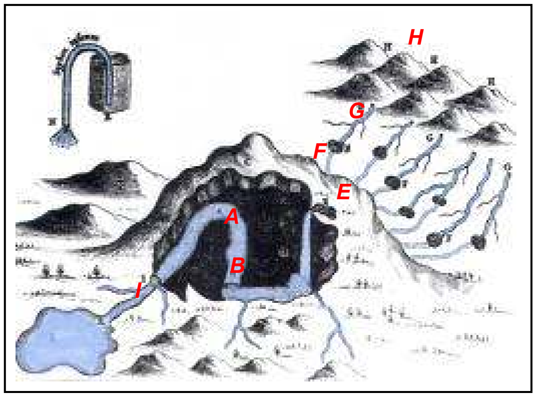


Crest and down-slope geometry must be such that when filled from the upstream side, flow deflects across the crest to fill the falling leg, at least as far down as the surface of the inlet pool.

The diagram to the right is not a true siphon, but rather only an inverted siphon flowing into a chute. The upstream reservoir will not be further drawn down.

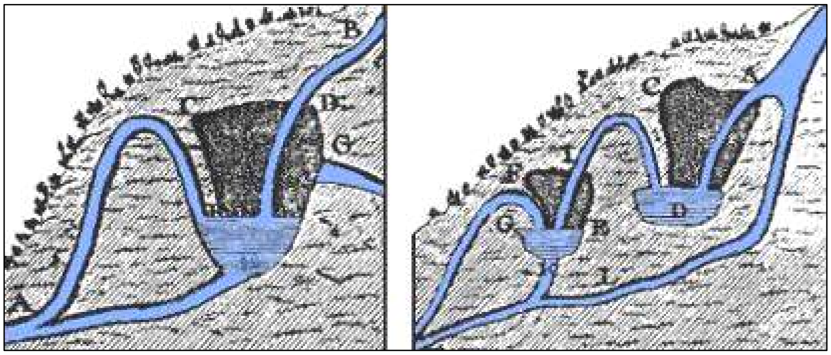
We noted in Chapter 10 that da Vinci envisioned siphons as an engine for mountain spring replenishment, and if a mind such as his wasn't encumbered by pesky physical limits, we shouldn't expect more of many who followed.

We'll note a few highlights of creative siphonry -- to coin a term -- over history.



As evidenced by his graphics, Athanasius Kircher was in awe of siphons. To the right is his explanation of intermittent springs -- one of his few original ideas -- as shown in Mundus Subterraneus (1665). Water sinking in the hills H rises again at G, flows on the surface and then disappears again at *F*. One of these sinks is shown again as *E* and the water passing through it fills the cave reservoir. When the head is sufficient, the water siphons up channel *BA*, emerging as an intermittent spring at *I*.

Note the siphon in the upper-left.



Mathurin-Jacques Brisson (1723-1806) included siphons in Planches du Dictionnaire de Physique (1781). His illustrations portray a degree of hydraulic sense.

In the spirit of Chapter 13, Hydrotheology/Theohydrology, Johann Scheuchzer's (1672-1733) Sacred Physics (1731) strove to explain the source of mountain lakes,

> *Other reservoirs of water resembled so many siphons, excavated internally in the chalk, sandstone and other substances that compost the bony parts of the mountains, and serving to supply the first springs of rivers, which take their rise sometimes from the tops of other mountains less elevated.*

Scheuchzer's is indeed a sacred physics, just not a worldly one.

Our mention in Chapter 19 of The Saddle Boys of the Rockies, or Lost on Thunder Mountain (1913) by Capt. James Carson included a reference to siphoning.

> *"Looks that way to me," Frank replied. "It is a great big siphon, and once started, the water that has for centuries been wasting in some underground stream is now flowing down this canyon. Perhaps long ago it did this same thing, till some upheaval -- an earthquake it might have been -- turned things around."*

How an earthquake might prime a siphon we're not told, but to his credit, Capt. Carson, recognized the requirement.

We'll encounter a true siphon, albeit a constructed one, in Chapter 59, Underground Aqueducts.

Intermittent Springs

Intermittent springs ebb and flow in cyclic manner.

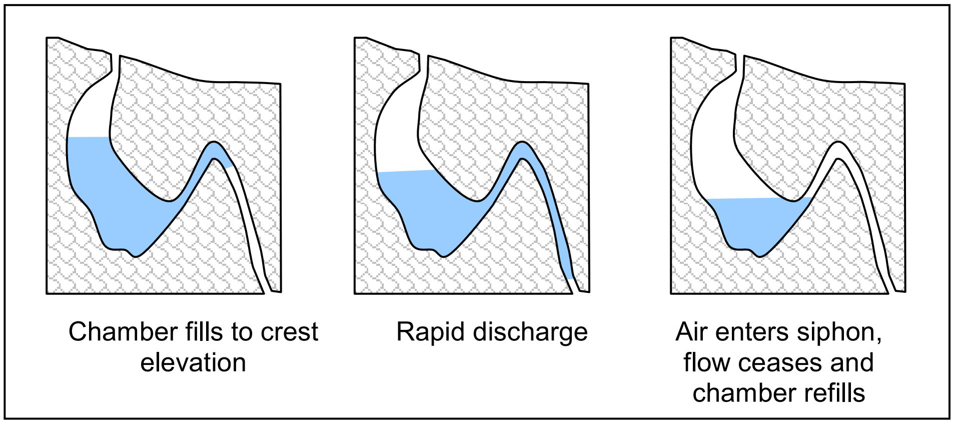
The Sambation River of Hebrew mythology was the demarcation beyond which the Ten Lost Tribes were exiled. Its foaming waters rise into the sky and an impenetrable wall of fire and smoke separates the sinless "little red Jews" from the rest of Jewry. The Sambation ceases to flow every Shabbat, the day Jews may not travel. The fiery nature brings to mind the subterranean River Pyriphlegethon of Greek lore (Chapter 1).

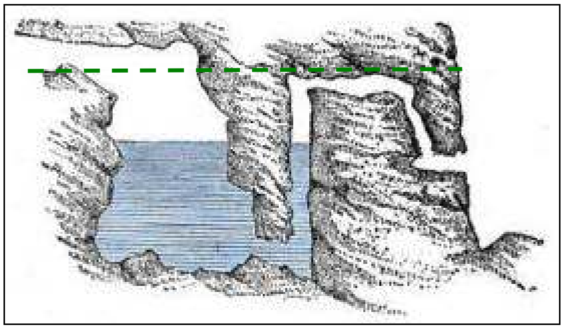
Pliny the Elder mentioned a river in Judaea that dries up every Shabbat and Pliny's contemporary Josephus spoke of the Sabbatical River that flows only on Shabbat. Medieval literature suggests that the Hebrew river is an active volcano, explaining the rapids, stones, fire and smoke.

Charles Hutton, whom we encountered in Chapters 11 and 12, hypothesized an intermittent siphon in A Mathematical and Philosophical Dictionary, Containing an Explanation of the Terms, and an Account of the Several Subjects (1795).

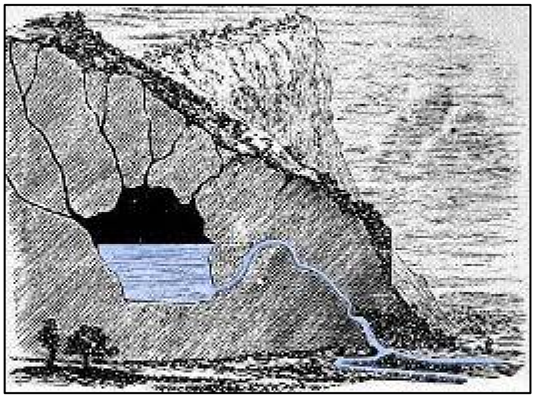
> *It is said that in the diocese of Paderborn, in Westphalia, there is a spring which disappears after twenty-four hours, and always returns at the end of six hours with a great noise, and with so much force, as to turn three mills, not far from its source. It is called the Bolderborn, or Boisterous Spring.*
>
> *There are many springs of an extraordinary nature in our own country, which it is needless to recite, as they are explicable by the general principles already illustrated.*

If the upstream reservoir's refill rate is less than the rate of siphoning, the reservoir will draw down to the siphon inlet, air will enter the conduit, and discharge will cease. When the upstream reservoir refills sufficiently to re-prime the siphon, discharge through the conduit will resume.


Chamber fills to crest elevation
Rapid discharge
Air enters siphon, flow ceases and chamber refills



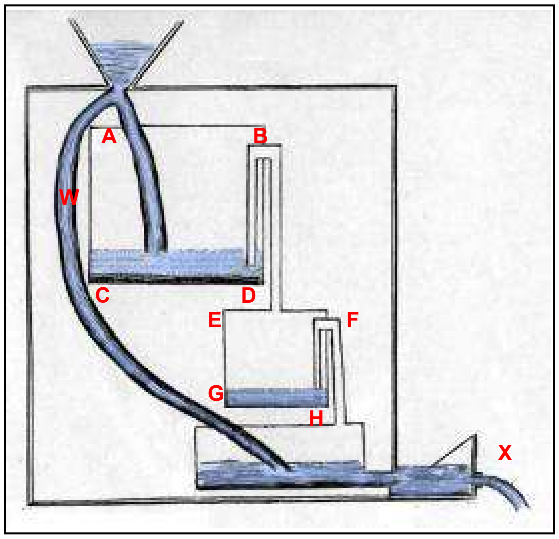
Cross-section of an intermittent spring from The Earth: A Descriptive History of the Phenomena of the Life of the Globe (1872) by Elisee Reclus. When the reservoir fills to the green line, the system primes and the reservoir drains to approximately the water level shown, the elevation of the siphon outlet.



The same from Elements of Natural Philosophy (1885) by Elroy Avery

Reclus' description of the intermittent process is accurate, but his comment regarding actual observation is more insightful.

> *After long periods of dryness, the spring entirely ceases to gush out; and the visitor who, on the faith of some old book, stands waiting, watch in hand, for the predicted appearance, runs a good chance of gazing vainly for many a long hour upon the dried-up basin of the fountain.*



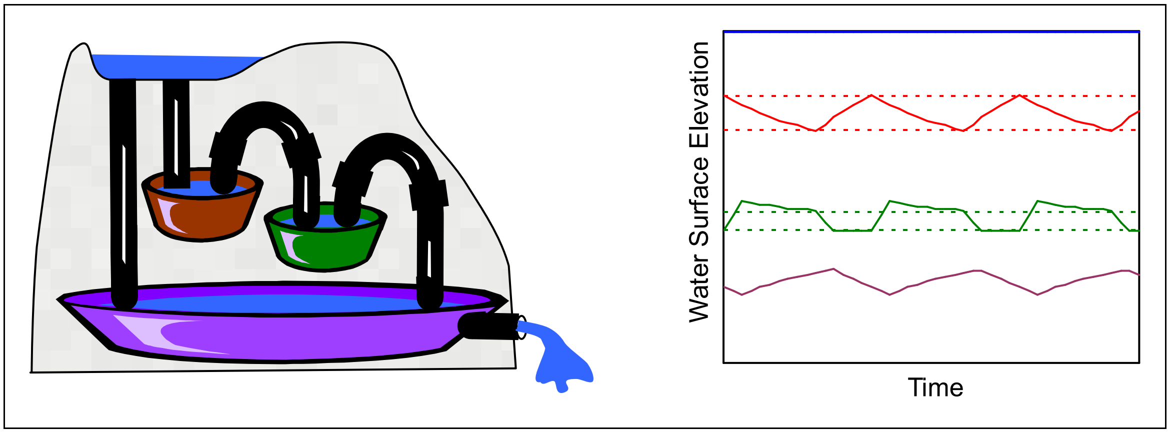
The behavior of an intermittent spring can be complex, but there have always been those up to the analytic challenge, as evidenced by "Conjectures upon the Nature of Intermitting and Reciprocating Springs," Philosophical Transactions 37 (1731-1732) by Joseph Atwell.

We quote just the essence of Atwell's proposition.

> *The spring is situated at one end of the town of Brixam near Torbay in Devenshire, and is known by the name of Laywell.*
>
> *Let us now suppose such a reservoir, with a constantly running stream W, and an outlet X, to receive the water of a siphon, coming through two reservoirs ABCD and EFGH.*
>
> *A fountain derived from X in this vase, would be an intermitting reciprocating- spring, whose stream would reciprocate, but whose reciprocations would sometimes stop, and have fits of intermission.*

A scheme such as Atwell's can mimic the Laywell springflow to some degree, indeed, but nature prefers simplicity.

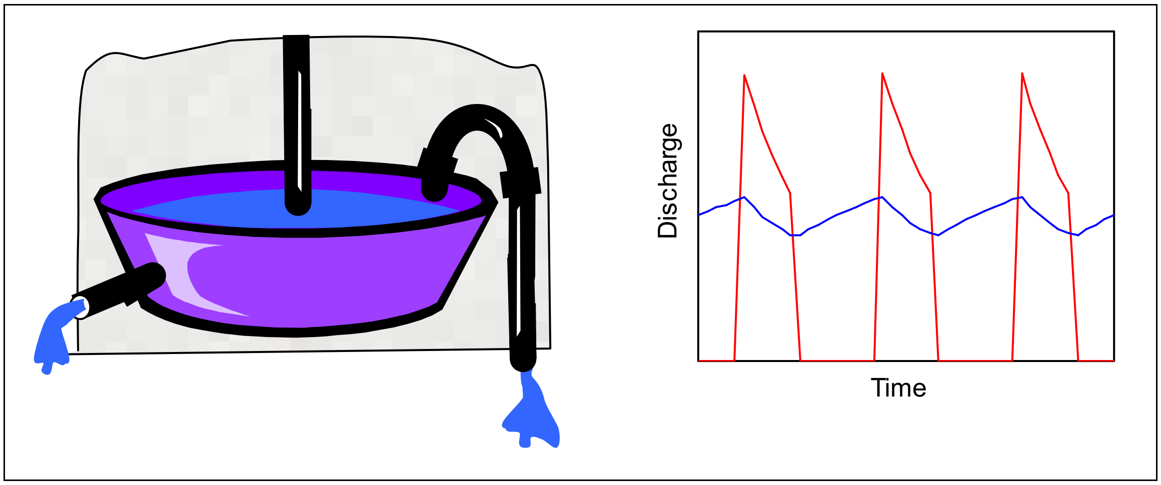
Below is our conceptual construction and numerical simulation of Atwell's hypothesis, the highest and lowest aquifers supplied by a headwater at constant elevation and the perched aquifers having siphon outlets.



Given the aquifer geometrics and the diameters and discharge coefficients of the various pipes, simulating the hydraulics is a fairly straight-forward computational exercise. The simulated water levels over 4.5 hours are on the right, the blue line representing the constant headwater and the red line, the off-and-on siphoning the red aquifer. The green line is more complex, as the green reservoir is fed according to the in the reservoir above, but discharges via its own siphon. The purple aquifer's oscillation reflects two inputs and its orifice outflow.

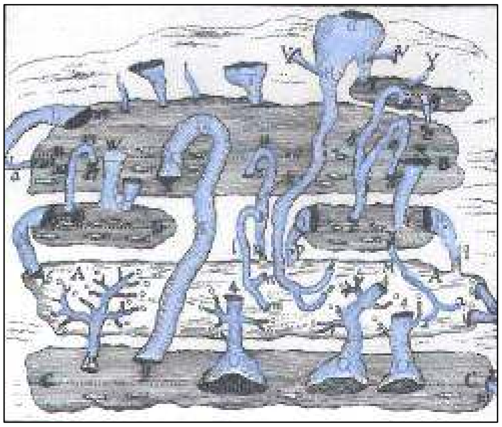
In adjusting the artificial system's geometrics and coefficients to produce an desired result is taxing, as in the vast majority of attempts, one or more of the reservoirs equilibrate at always-empty or always-full.

And while we're inventing, we'll build an apparatus generating alternating outflows from a common reservoir, one siphoned (the red line below), and the other (in blue), via a simple orifice.



The blue line decreases when the red line surges. We'll visit where such switching flow is said to happen in the United Kingdom in Chapter 51, The Tourist Trade Worldwide. Such plumbing, however, seem better suited for a science fair where we can tweak adjustments too delicate for the motor skills of geology.

We will learn more of the Zirknitzer See in Chapter 72, Underground and Balkanized, but here we note the siphon-linked sub-lacustrine cavern proposed by Johann Weikhard von Valvasor in Die Ehre dess Hertznogthums Crain (1689).



> *Beneath the surface lake lies an underground one connected by holes in the bottom. There are also one or more subterranean lakes beneath the Javomiki mountains south-west of the lake at a slightly higher level than the lake itself and they have their own exit passages which, under normal circumstances, drain the water received from underground streams as quickly as it arrives.*
>
> *When the lakes beneath Javomiki receive more than the exits can transmit, e.g., during thunderstorms, they overflow through other channels both into the Zirknitzer See subterranean lake, which then floods upwards through holes into the lake itself and by visible cave mouths such as Vranjajama and Suhadolica.*
>
> *It follows that in this rocky mountain there must necessarily be two hidden large lakes, and two smaller ones, and one very small one, that is a total of five lakes, together with their channels and siphons or raising tubes.*

Mechanical analogy is amply illustrated in Franz Anton von Steinberg's Grundliche Nachricht von dem in dem Inner-Crain Gelegenen Czirknizer-See (1758), three illustrations from which are at the right.

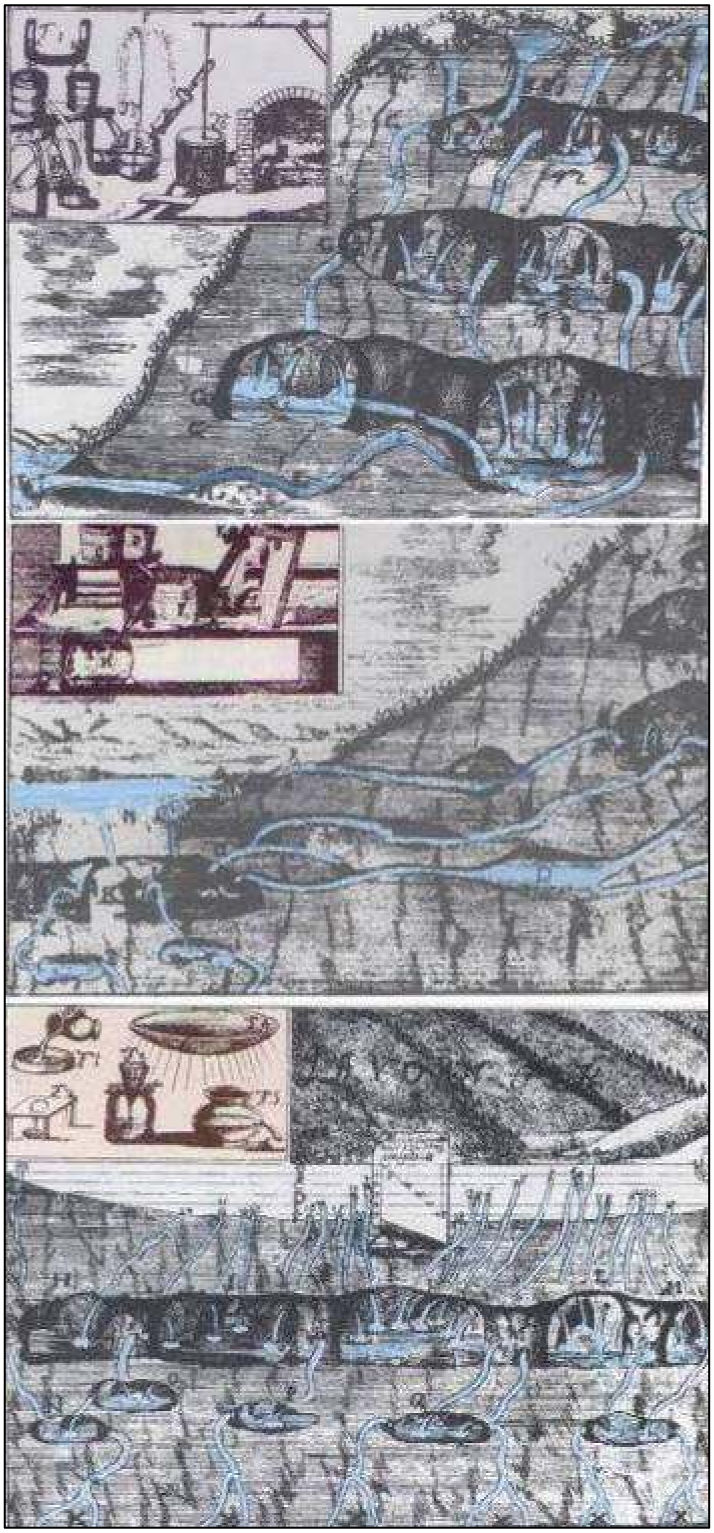
Each cross-section is modeled by a corresponding mechanical contraption in the upper left, here re-colored for visibility.

The top illustration claims to explain the lake's supply in terms of (among other items) a hearth, a weight, buckets and a pressurized sphere.

Infiltration from the higher ground descends to successive levels of caves and the flow from one level to that below induces draughts. The resulting air pressure forces the water to emerge at the spring.

The siphon in the lower passageway precludes the spring from functioning until rainfall raises the water level in the lower cave.

Beneath the lowest caves, some channels discharge directly into the lake and others, into a lower underground lake never filled to the roof and connected with the Zirknitzer See above by yet more channels. In times of drought, all water flowing into the lake is drained immediately and the lake remains dry. When the springs supplying the lake flow full, the holes in its bed cannot accept all the water and the lake level rises.



Ebbing and Flowing in the British Isles

Intermittent springs tend to occur more often in prose than on the ground. A feature said in an historical reference to be periodic can be checked against today's hydrologic databases where not uncommonly, the claim is not substantiated.

Let us consider a pair of long-reported intermittent springs in Britain, "ebbing and flowing" being the British designation. It's lighter on the tongue, perhaps, or maybe evokes the banter of a pub.

St. John's Well at Glamorganshire, Wales, was described by poet William Camden in 1607, "For as the Nymph doth rise the spring doth fall."

While folklore has long maintained the well's behavior to be something sacred, the cause was clear to R.D. Blackmore in The Maid of Sker (1872).

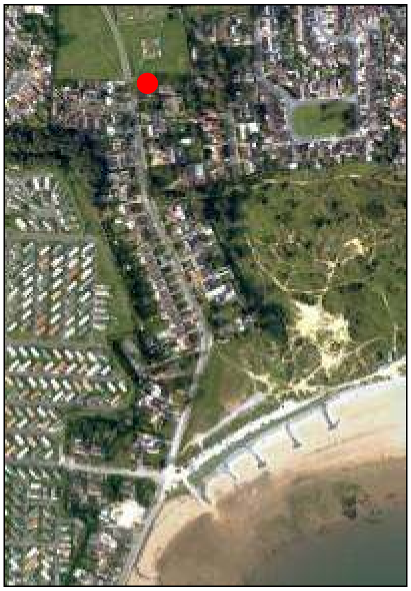
> *It comes and goes, in a manner, against the coming and going of the sea, which is only half a mile from it: and twice a day it is many feet deep, and again not as many inches. And the water is so crystal clear, that down in the dark it is like a dream. The children are all a little afraid of it... partly because of its maker's name... and partly on account of its curious ways and the sand coming out of its "nostrils" when first it begins to flow.*

From "Note on an Ebbing and Flowing Well at Newton Nottage (Glamorganshire)," Nature, May 12, 1898, by H. G. Madah,

> *A series of about forty observations made at intervals of an hour (and in many cases at the intermediate half-hours) during three consecutive days, enabled the author curve showing the relationship existing between the rise and fall of the tide on the coast and that of the water in the well. The result is to establish the existence of a wave in the well of the same frequency as the tidal wave, but delayed, or with an establishment of, three hours (plus or minus a few minutes). The analyses of water taken from the well at its highest arid lowest show no difference, so that no sea-water enters the well directly. On the other hand, the slight brackishness of the water appears to prove the diffusion of a small amount of salt water into the well.*

A follow-up Letter to Editor, "Ebbing and Flowing Wells," Nature, May 19, 1898, by W.F. Sinclair,

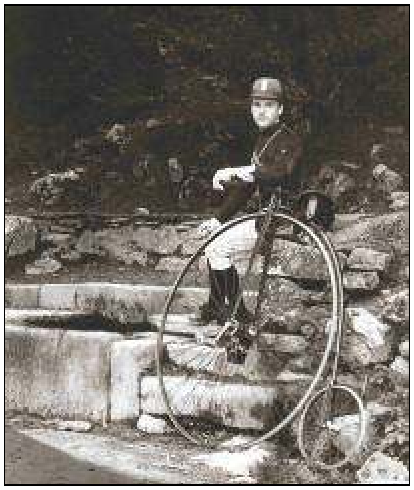
> *I have had occasion to live for many months of several years close to a well that was sometimes affected by the tide like that at Newton Nottage (Nature, May 12). This was at Alibag, a few miles south of Bombay. The bed-rock is a sheet of basalt of rather uneven surface, sloping westwards at the general rate of about six feet to the nautical mile. Over this, at the spot in question, were low sand-dunes, covered with palm orchards, and full of brick wells. One of my wells was twenty or twenty-five yards from true high-water mark of spring tides, though the surf washed light objects much nearer.*



St. John's Well toady, the well house having replaced an earlier low circular tower.

The cause of St. John's intermittency is the moon and the sea. The well is separated from the Severn Estuary by 500 meters of sand hills capped with a ridge of ballast pebbles from ships exporting limestone. The well is sunk into conglomerate overlying carboniferous limestone to about two-thirds of the difference between high and low tide. Incoming tide dams the fresh water, which rises in the conglomerate roughly 1 meter 3 to 4 hours after high tide on the shore.

The next well we will visit is in Giggleswick, North Yorkshire, and yes, that's the parish's name.



Giggleswick, 1885

EBBING AND FLOWING WELL,
SETTLE

Early 20th century

As described by John Speed in England and Wales Described (1627),

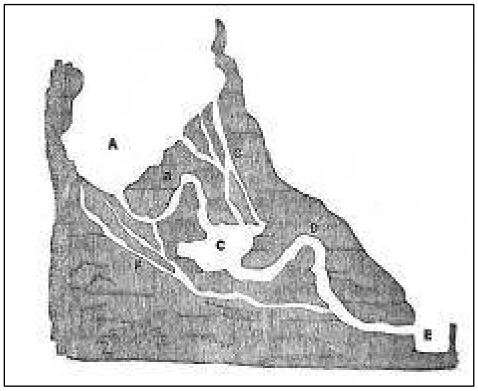
> *At Giggleswick... there are certain small springs... the middlemost of which doth at every quarter of an hour ebb and flow about the height of a quarter of a yard when it is highest, and at the ebb falleth so low that it be not an inch deep with water.*

English Romantic poet William Wordsworth (a contemporary of Samuel Taylor Coleridge, Chapter 30, Down to a Sunless Sea) mentioned the well in A Guide to the Lakes (1844).

> *Beyond Settle, under Giggleswick Scar, the road passes an ebbing and flowing well, worthy the notice of the Naturalist.*

From An Illustrated Guide to the Curiosities of Craven (1850) by William Howson,

> *During a very dry, or a very rainy season, the reciprocation almost entirely ceases, but when there is a medium supply of water it is commonly in full activity, rising and falling rapidly, sometimes without intermission. The distance between its flux and reflux varies form a few inches to half a yard. Different explanations of this phenomenon have been given, but none has satisfactorily accounted both for the reciprocation and its irregularity, as well as for the influence of the wet and dry seasons, until a solution on the principal of the double siphon was given by the late ingenious Thomas Hargraves of Settle. A model was constructed by him, which exactly exhibited the eccentric habits of the well; it is now deposited in the Library of the Settle Mechanics' Institute.*



Howson then summarizes Hargraves' explanation, a siphon scenario for which we could construct another plumbing model for mathematical simulation if we saw the need.

The "half a yard" observation more than two centuries after Speed's "quarter of a year" makes it clear that intermittency remained a noteworthy characteristic.

The lack of amplitude quantification in "In the Heart of a Hill," Harper's New Monthly, December 1872, is more than made up for by the prose.

> *The* [Yorkshire] *hills of Craven... contain in their stony bosoms undreamed of dwelling-places, caverns, halls, and passages into which has never penetrated the light of day.*
>
> *Perhaps this accounts for the strange noises that are heard in lonely spots upon the hills in Craven, gruntings and grumblings underfoot, which the man of science explains by the roar of subterranean streams, but which may, after all, be the curses not loud but deep of discrowned gods -- Jove throwing a thunder-bolt in impotent wrath, or Vulcan striking an impatient blow on a stalagmite by way of anvil. For these sounds, curiously enough, are often intermittent; there is an ebb and flow in these underground waters, produced, say the learned, by a sort of natural siphon. Besides these marvels, there are pots, deep natural wells, rounded as though by the hand of man, but of solid stone, at the bottom of which are running streams; and even boiling pots, where the dark water rises to the surface and churns over, and then returns to its deep channel to thud and gurgle as before, unseen.*

From "Giggleswick: Ebbing and Flowing Well," in "Holy Wells," The Antiquary 23 (1891),

> *This celebrated well is situated at the foot of Giggleswick Scar, a limestone rock about a mile from Settle, going toward Clapham. The water periodically ebbs and flows at varying intervals, depending upon the quantity running at the particular time. Sometimes the phenomenon may be observed several times in the course of one hour, and on other occasions once only during several hours.*

The sources agree that the period varies over time.

Yorkshire Legends and Traditions as Told by Her Ancient Chroniclers (2003) by Thomas Parkinson adds that the rise and fall is "several inches," going on to say,

> *At one time it was thought there was some subterranean connection between the waters of this well and those of the ocean, and that the ebbing and flowing of the tides led to the rise and fall of the waters in the well. This is an improbably and unsatisfactory explanation. The true one is probably to be found in a system of natural siphons in the limestone rock. The theory that such is the case has been well worked out by a gentleman of the locality, whose name the writer is sorry he does not remember.*

Given the 40 kilometers to the Irish Sea, Parkinson is correct is dismissing tidal action. As for the forgotten theorist, might it not be Thomas Hargraves, whose work is deposited in the Library of the Settle Mechanics' Institute?

From "The Mysterious Underworld," Hydrocarbon Processing 79:2, February 2000, by Cris Whetton,

> *In Britain's north Yorkshire, there is a curious well in which the water regularly -- and mysteriously -- rises and falls. Not surprisingly, it is known as the Ebbing and Flowing Well. While no one has seen the underground structure that feeds this well, any engineer can hypothesize a system to account for this phenomenon. The most likely possibility is an underground rock chamber and siphon arrangement.*
>
> *Although the siphon has been known since classical times, the well was considered a mystery -- even magic -- into the early Twentieth Century. Most underground things are a mystery.*

"Most underground things are a mystery." But needn't be, we suggest.

The Giggleswick well is no longer the tourist attraction of postcard days and recent videos show oscillations more akin to ripples. Given the behavior reported in earlier times, perhaps the hydrologic system has altered.

Ockham's Razor

A reported intermittent spring might be due to

1. Misperception of a temporal trend where in fact none exists. Any number of factors may cause random oscillations of small magnitude in a water surface, critical hydraulic conditions in an inflow conduit being one possibility.
2. Tidal action in coastal zones. If the seawater wedges beneath the freshwater lens, the well water may remain potable. The well's oscillations will lag behind those of the tide.
3. Cycles of water withdrawal or diversion within the watershed.
4. True siphoning requiring both strict geometric requirements and a narrow range of discharge.

Let us recall Ockham’s razor from Chapter 10.

> Given competing hypotheses that each seem to account for a phenomenon, the simpler explanation is more likely to be the correct explanation.

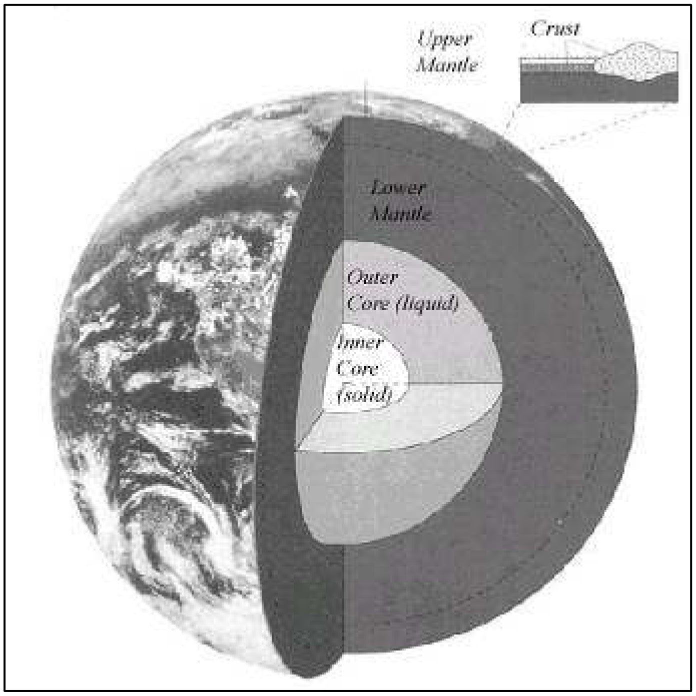
Applying Ockham's razor to candidate hypotheses for intermittent springflow, siphoning rarely emerges as the most-likely cause.

CHAPTER 45
SUBTERRANEAN GEOPHYSICS

Regarding a fiery earth, Athanasius Kircher, our Jesuit of indefatigable imagination (Chapter 8), wasn't as far-fetched as sometimes portrayed. Although it not Kircher's central fire that pumps our terrestrial springs, it is the earth's molten core that explains much of how the earth has come (and is yet coming) to be.

The earth's relatively light and brittle crust extends about 40 kilometers beneath the continents and somewhat less below the oceans.

For perspective, the deepest borehole drilled for scientific purposes, 12 kilometers, is located on the Kola Peninsula near Murmansk, Russia. It took 24 years to drill. If the earth were reduced to a tabletop globe, the Kola borehole would be the equivalent of its paper skin.



But the Russian endeavor is to only half the depth of "Mel's Hole," somewhere near Ellensburg, Washington. Phoning into the radio show "Coast to Coast with Art Bell," February 21, 1997, the hole's discoverer, Mel Waters, estimated the depth by plumbing with a lead fishing weight. Note Mel's method for hydrogeologic assessment.

Mel: *Well when I let out the first fifteen hundred yards of line I reeled all of that back in and I wanted to know if I had hit water down there because I thought that is a lot of feet.*

Art: *You bet.*

Mel: *That's forty five hundred feet of line. Did I hit water? So I did. What I did was I sent down a roll of lifesavers.*

Art: *Lifesavers?*

Mel: *Yeah, so when it hits the water the lifesavers will dissolve.*

Art: *That...oh I see... very smart!*

NEW FLAVORS!
LIFESAVERS
5 FLAVOR

Mel's revelation generated considerable interest in Washington newspapers, but as "Mel Waters" has not otherwise revealed himself and enthusiastic hiking groups have failed to find the site, the remarkable geologic feature seems to be lost.

But back to more-accepted geology. Intruded into the crust are bubble-like pockets of magma, “plutons,” typically at a depth of 6 to 14 kilometers. Below the crust the lies the 2,900-kilometer thick mantle of ferro-magnesium silicates flexible enough to flow instead of fracture.

We'll say just a bit about the magma, as it flows as underground rivers, just not ones of water.

Viscosity refers to the ability of a substance to resist flow, in fluid mechanics jargon, the ratio of shearing strain to the of differential of shearing strain with respect to distance from the boundary. As shown to the right, motor oil has a higher viscosity than does water.

	Viscosity (Pascal-second)
Water	0.009
Motor Oil	0.065
Lava	150 to 3000

Some 100,000 times more viscous than water, lava can flow great distances before solidifying because of its thixotropic nature, a property of certain gels and fluids, such that when shaken, agitated or otherwise stressed, they become less viscous. Ketchup is also thixotropic.

A magma's viscosity is largely controlled by its temperature, composition, and gas content.

The higher the temperature, the lower the viscosity.

The higher the silica content, the greater the degree of polymerization and the higher the viscosity.

When gases begin to escape (exsolve) from the magma, the viscosity increases.

Lavas with high viscosity include rhyolite, dacite, andesite and trachyte. Such lavas

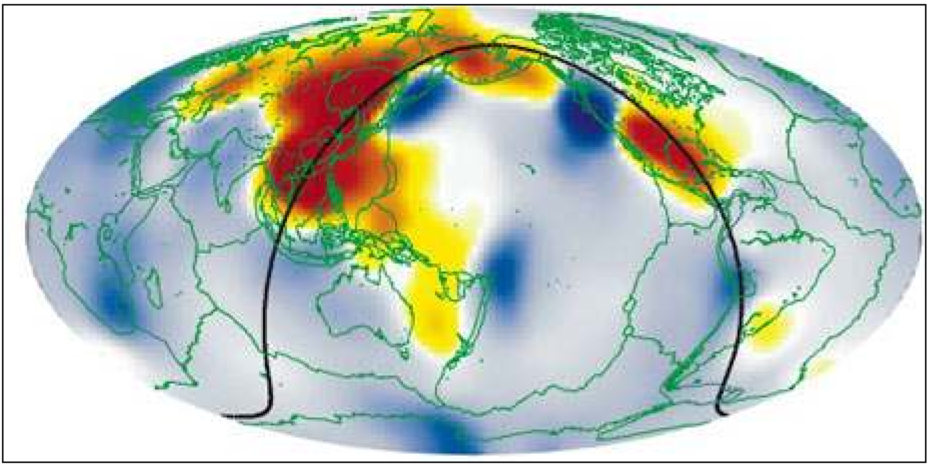
Tend to flow slowly, clog, and form semi-solid blocks which resist flow
Tend to entrap gas, which form vesicles (bubbles) within the rock as they rise to the surface
Tend to be associated with explosive or phreatic eruptions
Tend to form explosive fragmental ash or tephra deposits.

Lavas with low viscosities include freshly erupted basalt, carbonatite and occasionally andesite. Such lavas

Tend to flow easily, forming puddles, channels, and rivers of molten rock
Tend to easily release bubbling gases as they are formed
Tend to form broad shields rather than steep cones

As basaltic melt has a low silica contents, exsolved gasses escape without a significant increase of pressure. The result is a relatively-calm eruption with lava extruded over great distances.

About as much water as that contained in the Arctic Ocean is locked in moisture-containing rocks 700 to 1400 kilometers beneath eastern Asia. But we shan't explore this sea by submarine, as the water constitutes probably less than 0.1 percent of the rock volume. The map depicts the wet underground rock (shown in red) as detected by seismic waves.



.

The water arrived by the process of plate tectonics, in which the sea floor is pulled beneath continental plates. Normally the earth's internal heat bakes the water out of the rocks before it intrudes more than 100 kilometers and the water escapes as volcanic gas. In this case, however, conditions allow the water to be drawn much deeper.

There's no water further down where the molten nickel-iron outer core, radius 3480 kilometers, produces the earth's magnetic field.

Because the 1255-kilometer radius inner core is at 3.5 million times surface pressure, iron solidifies, though the temperature is between 5000 and 7000 degrees C. (The surface of the Sun is 5500 degrees.) It is not known why the earth's core is hot, but geophysics suggests that the heat is a legacy of the earth's formation.

Geysers

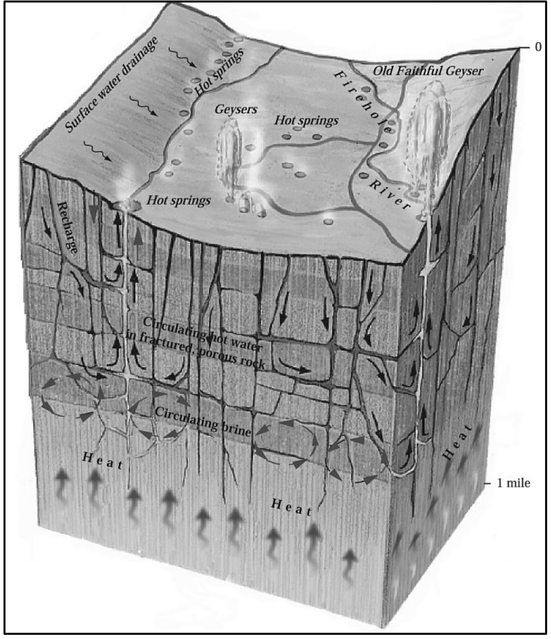
The U.S. Geological Survey defines a geyser as a hot spring characterized by intermittent discharge of water ejected turbulently and accomplished by a vapor phase.

To understand hot this happens, we'll begin with Manual of Geology, Treating of the Principles of the Science with Special Reference to American geological history, for the Use of Colleges, Academies, and Schools of Science (1862) by James D. Dana.

> *Hot springs are common in volcanic regions. The waters may be pure, or of a mineral character. In Tuscany they give out boracic acid. In Iceland they are large and move in intermittent jets, and are called Geysers. The tossing of the water, which is in some cases to a height of 200 feet, is supposed to be owing to a sudden production of steam in chambers beneath. The stream, like any other subterranean stream, may have its head in the mountains. But it comes in contact with the hot rocks, and the heat and geyser-movement is the consequence. It has been suggested that the waters are temporarily in the spheroidal state from contact with the lavas below; and as they increase by additions, after an interval, they suddenly fall below the temperature requisite for this state, and then the explosion or jet takes place.*

That's almost correct, given the scientific vocabulary of the time, the factual error being the assertion of inflow via a subterranean stream. It's just the locally percolated rainwater.

All geysers lie above recently active volcanic area where magma is close to the surface, e.g., 56 kilometers below in Yellowstone, compared to 125 kilometers under most land areas.



In most regions of the earth, the temperature gradient is about 2.5 degrees C/100 meters of downward depth. A test well drilled in Yellowstone during the late 1920s revealed a temperature of 210 degrees at a depth of 85 m, an astonishing 224 degrees/100 meters.

At Yellowstone, precipitation percolates to a depth of about 2 kilometers where it is heated to 260 degrees or more, but cannot turn into steam because of the pressure.

The superheated (and thus less dense) water works its way back up through subterranean fissures until pressure is released near the surface and the sudden expansion in volume triggers a geyser eruption. Old Faithful sends up 32 cubic meters of water as high as 56 meters on an average of every 85 minutes. Steamboat geyser, the largest geyser in the world, can throw water 91 meters into the air. The water's journey from the surface down and back up via a geyser can take 500 years.

A Lesbian News, August 2007, travel suggestion,

> *California's Old Faithful: A Dancing Water Show*
>
> *Water for the Old Faithful Geyser of California comes from an underground river. When it flows over molten magma deep in the earth, the water boils and expands. The heat supplies pressure to move that water upward, through the fissures and fractures, until it pours out in steam and hot, dancing water.*

We could have quoted any number of travel guides, but we like the idea of underground rivers that welcome all of us.

But are geysers underground rivers?

Perhaps, but they are vertical and intermittent.

A theory of springflow temperature proposed by Elisee Reclus in The Earth: A Descriptive History of the Phenomena of the Life of the Globe (1871) is based on the earth's thermal gradient.

> *The depth to which the water descends into the bowels of the earth maybe approximately ascertained by the temperature of a spring. It may be confidently affirmed that, in a general way, cold springs -- that is to say, those the mean temperature of which is lower than the heat of the soil -- descend from mountains, and that thermal springs proceed, on the contrary, from beds lying deep in the interior of the earth.*

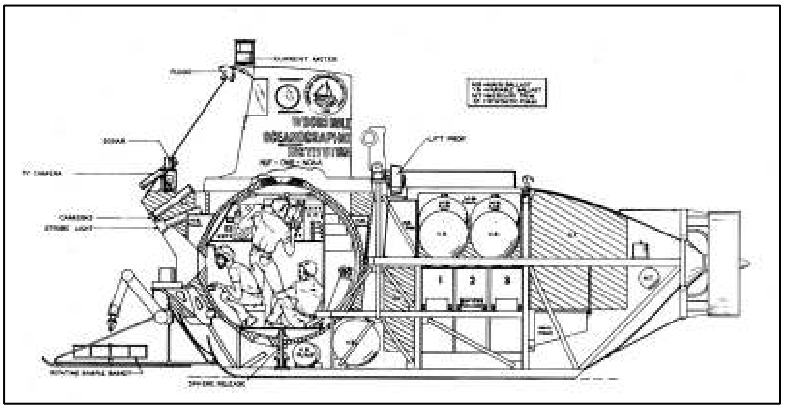
While the theory has merit in concept, its practical value is small. The air-cooling proposition is erroneous, as evaporation is negligible from open subterranean channels; the overlaying air tends to be near full humidity.

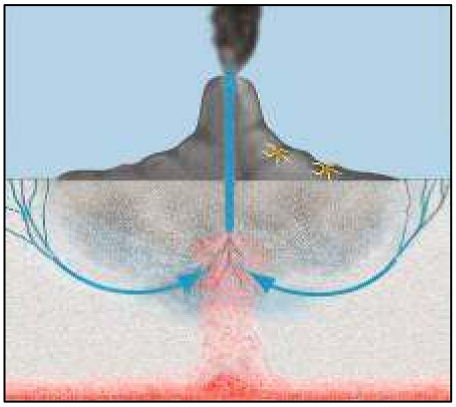
> *Geologists who have applied themselves to the study of subterranean hydrography have had many opportunities of proving the truth of the fact that drainage waters at first maintain a temperature considerably lower than that of the rocks. This is so because, in addition to the water, the air also enters the subterranean channels and circulates in all the network of clefts and crevices, and, by incessantly gliding over the wet sides of the channels, produces a rapid evaporation of moisture, and, in consequence, refrigerates the surface of the rocks and even the stream itself. The temperature, therefore, of springs which proceed from the interior of cavernous mountains is always several degrees lower than the normal temperature of the soil.*

Springflow in general tends to be several degrees cooler than the soil because the latter is exposed to the sun.

Black Smokers

In 1977, scientists on the research submersible Alvin discovered "black smokers" near the Galapagos Islands, deep-sea chimney-like hydrothermal vents made of sulfur-bearing minerals.





Sea-floor volcanic eruptions form deep cracks, kilometers deep in some cases, into which seawater intrudes where it can be superheated to 350 degrees. The water can't vaporize, however, because of the pressure, and returns to the surface.

If we envision the black smoker phenomenon as the river Pyriphlegethon of Chapter 1, we might classify the subterranean pathway as subsurface streamflow, albeit vertical like a geyser, but without interruption.

Black smoker water garners a rich variety of minerals, including sulfur, copper, zinc, gold, and iron. As it mixes with the 2ˉdegree sea water, the outflow cools and precipitates much of the mineral load. The smokestack effect is due to the residual heat and sulfur.

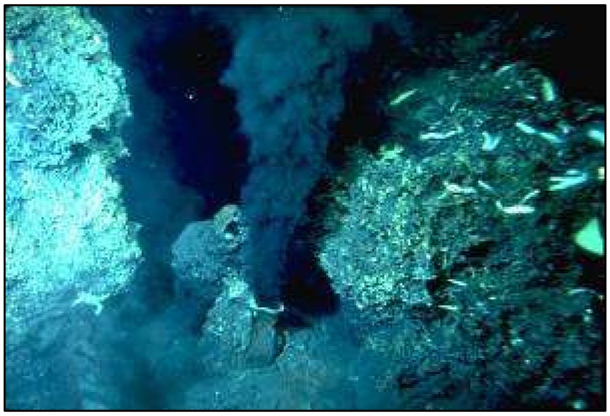
Kircher described seawater channeled to the earth's furnaces from where the heat causes the water to ascend, forming deposits of "Ferrum, Sulphur, Aqua dulcis, Sal, Nitrum, Nitrum, and Vitriolum."

Ferrum	Iron
Sulphur	Sulfur
Aqua dulcis	Fresh water
Nitrum	Potassium nitrate or sodium nitrate
Vitriolum	The alchemic acronym for "Visita Interiora Terrae Rectificando Invenies Occultum Lapidem Veram Medicinam," meaning "Visit the earth's interior, and by rectifying you will find the hidden stone which is the true medicine."

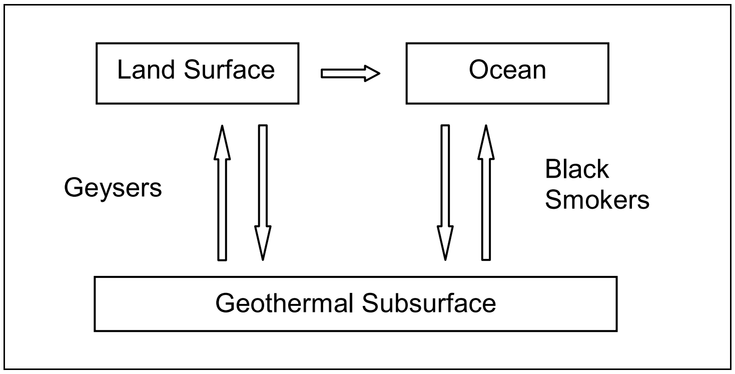
Other than the last, Kircher was very close. On further reflection, he may have been correct regarding vitriolum, as well.

The largest black smoker yet discovered, nearly 50 meters high and 180 meters in diameter, lies 3,650 meters below the mid-Atlantic.

Scientists estimate that such circulation of seawater through the oceanic crust accounts for 34 percent of the heat input into the global oceans. It takes 6 to 10 million years for a subterranean turn-over of the ocean's volume.



Here's the schematic.



For those seeking yet-more catastrophic sub-oceanic springs, Branton, with whom we'll become better acquainted in Chapter 86, The Rio San Buenaventura, offers this biblical hypothesis.

> *Some* [scientists] *however believe that there is evidence for the existence of a vast global network of CRUSTAL geothermal and hydrothermal cavities, some of these having been connected to the ancient deluge wherein the "fountains of the great deep were broken up." This allegedly occurred as magma-heated stratas of subterranean water-filled caverns (brought to enormous pressures by an expanding and over-heated mantle) suddenly burst through the crust (Gen. 7:11), like a pressure boiler of enormous proportions suddenly splitting it seams.*
>
> *It is not difficult to imagine that such a cataclysm may have caused the sinking of ancient land masses as the underlying mega-aquifers emptied out and the overlying layers lost their support. Vast amounts of this overheated water -- which had previously been dissolving the basaltic rock layers surrounding it -- exploded to the surface, thus explaining why the oceans now contain a large percentage of "salt" content. These underlying chambers, many of which*

> *collapsed yet many of which apparently remained intact, are believed to exist throughout the moho and crustal regions of the planet, just above the upper mantle.*

Kircher, Branton and the Alvin scientists are in accord that scalding subterranean rivers flow into the deep blue sea.

CHAPTER 46

FINDING THE UNDERGROUND RIVERS

What can we make of underground streams if we can't even find their channels?

We'll begin with how discovery works in general, a Roman method for locating underground water and then two approaches to find underground rivers -- dowsing and geophysics.

Five steps are required to detect anything.

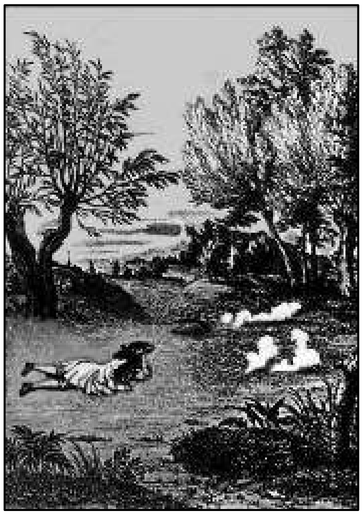
Steps to Discovery'

Excitation	The hearing of a bell requires that something activate the signal, a clapper, for example. We'll call this an "external" excitation. The recognition of a rose, on the other hand, needs nothing done to the flower. We'll call this an "internal" excitation.
Emission	With or without our help, the object of our search must emit some sort of signal. The signal is might be thought to be an energy wave which may or not be of a type recognized in a physics laboratory, but might be olfactory particles or even some sort of subatomic projection.
Transmission	Whatever is emitted needs to reach the observer.
Reception	The signal must be received, albeit via extra-sensory perception, a radar dish or anything between.
Recognition	The observer needs to recognize the reading. A technician may lack first-hand sense of the processing within a laboratory instrument, but can read a dial or see a flashing light. When reception is not if the instrumental variety, however, recognition may involve additional mental process

Let us apply the steps to Vitruvius' De Aquis (Chapter 3) suggestion for finding subsurface water.

> *Just before sunrise, lie face downwards on the ground, resting your chin on your hands. Take a look over the countryside; where you see vapor curling up from the ground you will find water where you dig.*

The method, as depicted in the 15th century -- note the hats -- is shown to the right.



Vitruvius' Vapor Method

Excitation	As the investigator does nothing to initiate the vapor, the excitation is internal.
Emission	The vapor would seem to be a consequence of evaporation, a phenomenon well known in Romans times.
Transmission	As Vitruvius is concerned with underground water, the vapor must travel through the soil to the surface.'
Reception	Per the illustration, vapor is visible to the eye.
Recognition	There's nothing subconscious about this. The observer knows what he sees.

Though some of the steps seem to be physically unlikely -- e.g., the puffs of visible water vapor -- the process requires nothing not scientifically understandable.

Vitruvius also suggested placing a bronze bowl in a pit overnight. If the bowl collects condensation, there's water below. Again the validity is questionable, but at least it's based on the science of the day.

The science of the 19th century, too, if we believe Ballou's Monthly Magazine of March 1880.

> *It is stated in a French scientific periodical that underground eater may be discovered by observing the quivering of the air on a clear summer afternoon when the sun is low. If a well is dug at the spot where the quivering appears, a supply of water will there be found.*

Dowsing

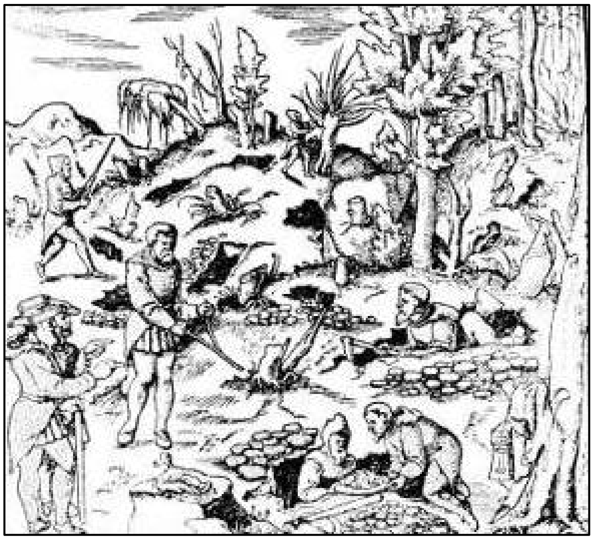
The profession of water dowsing is also referred to as "water divining" or "water witching." We can use "rhabdomancy" or "radiesthesia," however, if we need to sound authoritive.

A bit of dowsing history.

Dousing was practiced by the Egyptians in 3,000 BC, but the earliest purported suggestion of the art is an 8,000-year-old Atlas mountain cave mural of a man standing with a forked stick. We'll stick with the Egyptians.

Herodotus (480-430 BC) wrote of willow divining rods used by the Scythians, a nomadic Persian people who traveled the prairies of what today is southern Russia. Reference to willow divining rods appears 800 years later in a Roman history by Ammianus Marcellinus. Mention is also made of divination by Germanic tribes to the north. Basil Valentine, a Saxon Benedictine monk and alchemist, wrote instructions for divination in the 1300s.

Martin Luther (1483-1546) rued that dowsing was "the work of the devil," and hence the term "water witching." As dowsers shrouded their craft in mystery, it is not hard to believe that some would think them evil doers. On the other hand, medieval dowsers were knows to baptize their rods so that they might address their tool by a Christian name.



Agricola (Chapter 9) included a woodcut in his De Re Metallica of dowser cutting a branch from a tree while two others excavate. Agricola, however, rejected dowsing because it simply was not useful.

> *A miner...should not make use of an enchanted twig because...a forked stick is of no use to him, for there are natural indications of the veins which he can see for himself without the help of twigs.*

In 1912, De Re Metallica was translated into English by future president, Herbert Hoover.

Kircher (Chapter 8) experimented with wooden rods said to be sympathetic to certain metals by placing them on pivots, but they never turned on the approach of metal. A similar course of experiments over water, however, caused him to attribute to the rod the power of indicating subterranean watercourses. “I would not affirm it," he concluded in De Arte Magnetica (1643), "unless I had established the fact by my own experience.”

Claude Dechales, another Jesuit, author of a treatise on natural springs, declared in his tome Mundus Mathematicus (1674) that no means of discovering water exceeds that of the divining rod, citing an acquaintance who with a hazel rod could discover springs and trace the course of a subterranean conduit.

M. de Saint-Romain, in his Science Dégagée des Chimères de l'École (1679) declared,

> *Is it not astonishing to see a rod, which is held firmly in the hands, bow itself and turn visibly in the direction of water or metal, with more or less promptitude, according as the metal or the water are near or remote from the surface.*

In 1691 Jean Nicholas de Grenoble published La Verge de Jacob or l’Arte de Trouver les Trésors, Les Sources, les Limites, les Métaux, les Mines, les Minéraux et Autres Choses Cachés par l’Usage du Baton Fourché (The Rod of Jacob or the Art of Finding Treasure, Springs, Boundaries, Metals, Mines, Minerals and Other Hidden Things by the Use of the Forked Twig).

Dowsing involves methods for which the scientific basis is sketchy, but whose advocates suggest that such foundation surely exists. Here's a suggestion of an explanation, for example, from the New Tip Top Weekly, an Ideal Publication for the American Youth, March 28, 1914.

> *Although the divining rod as a locator of underground water for springs and wells has been denounced as a fake by Federal authorities, and is not given the most implicit confidence even in remote rural communities of the United States, experiments in German South Africa have located water at subterranean depth in 70 per cent of the tests.*
>
> *The department of agriculture of the French republic is seriously investigating the divining rod, and an association having five hundred members in Stuttgart, Germany, has begun laborious tests to determine its real value.*
>
> *French publicists and scientists have taken up the personal-magnetism phase of the question. It is held by some that considering the surprising discoveries of late in regard to radiation of all sorts, it may be that there is some radioactive influence of underground waters which may act physiologically on the organism of the person in whose hand the rod seems to turn toward the subterranean water.*

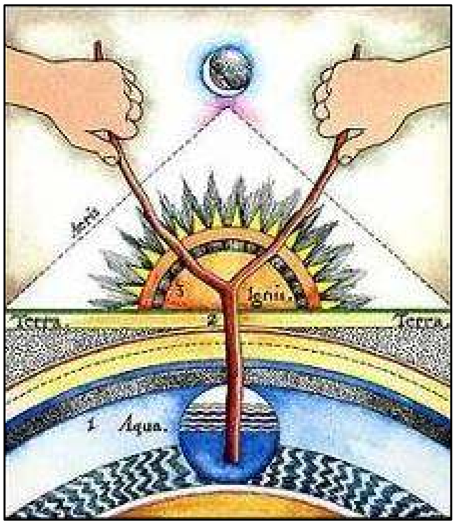
One might fault a 1914 reference, but the "radioactive influence" is scientifically on par with alternative mechanisms suggested in the intervening years.

According to Water Witching U.S.A. (1979), a sociological study by E.Z. Vogt and R. Hyman, the most consistent belief among dowsers is that underground water flows in "veins" which "may vary in magnitude from the size of a pencil to underground rivers."

Dowsers specialize in underground rivers, not broad zones of a saturated subsurface for two reasons:

Movement of the water is frequently thought to be a key to the signal, and

If the water weren't confined to relatively-narrow waterways, they would be no need dowser.



As for dowsing's efficacy, here's an account from the Daily Herald, May 12, 1900,

> *Mr. Austin Mallory, of Franklin County, Ky., set off not long ago to dig a well. A driver with a witch-hazel switch picked out the spot where water was to be found by digging, and the well was begun. Six feet below the surface a solid rock was struck, but Mr. Mallory persisted and blasted away down forty feet, when in few days ago a blast blew the bottom out of the well, and hen found that he had opened the way to an immense cave. Three of four bold spirits ventured down into the cavern. Wandering about the explorers came upon a small river of crystal clearness, in whose waters strange-looking fish disported themselves, and whose merry ripples hand furnished music for centuries with no other audience than the eternal rocks. A pool of water was also found which, as far as they could sound, was bottomless. On the banks of the stream was found the wreckage of what had once undoubtedly been an Indian canoe, drifted there, doubtless, from some other water course and preserved so long by the pure atmosphere of the cave.*

Not bad results for a twig of witch-hazel, we must agree.

Dowsing instruments commonly include:

A forked stick held parallel to the ground by the top of the Y,
Two L-shaped rods, one in each hand parallel to the ground and parallel to each other,
A long slender tapered stick,
A pendulum.

The fact that the instruments are varied speaks to the "ideomotor effect," a concept credited to William Carpenter in 1882 in which an involuntary body movement is evoked by an internal process rather than by sensory stimulation. A dowser may lack consciousness about the received signal, but can transmit that information to a forked stick which can be seen.

Dowsing is thus perhaps more about the dowser than what's held.

Dowsing's scientific hypotheses -- we use the plural, as there are many -- tend to employ nomenclature evoking respect, but the underlying understanding is often askew. The table below lists alternative explanations of the groundwater signal that dowsers process, though some of the listed scientists may feel that their theories have been hijacked.

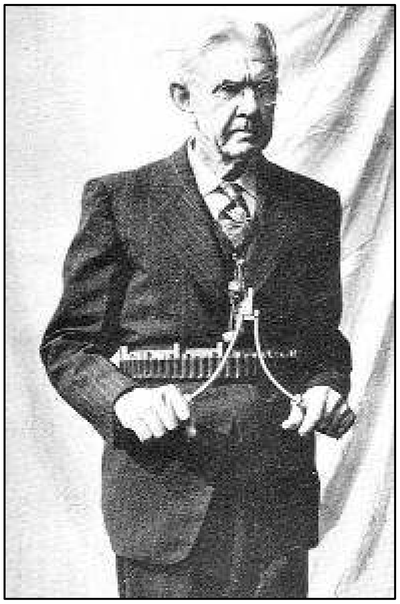
Biogravitation	Alexander Pavlovich Dubrov	Russia
Fields from underground tensions	Nils-Axel Mörner	Sweden
Infra-red light	Gustav Freiherr von Pohl	Germany
Ionization	P.E. Dobler	Germany
Neutron radiation	Dieter Aschoff	Germany
Thermal neutron radiation and microwaves	K.E. Lotz	Germany
Electro-kinetic currents	Urs Häfeli	Switzerland
Attraction of likes	Clarence V. Elliott	United States
Electromagnetic fields		
Earth energies		

We'll confine our look to the last three.

From Water Witching U.S.A. (2000) by Evon Z. Vogt and Ray Hyman,

> *Clarence V. Elliott, of Los Angeles, demonstrates dowsing equipment of his own design. The forked metal rod has a detachable top in which can be fitted samples of the substance sought; the containers are carried, ready to hand, in a cartridge belt.*

Eliot's belt of samples would seem to support a like-attracts-like explanation of dowsing, an idea that's not been furthered.



Electromagnetism is today's most common dowsing explanation, resolutely pursued since the ocean-to-springhead mechanism-frenzy we saw in Chapter 8. Magnetic fields and electromagnetic fields are not the same, however. A magnetic field is static, e.g., that of the earth or a magnet. An electromagnetic field is generated from an alternating energy source such as a power line or a radio transmitter.

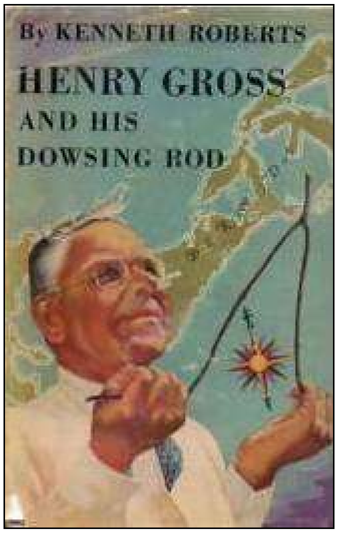
Water contains hydrogen nuclei which carry a charge and do respond to magnetic fields, but only to the infinitesimal degree discussed in Chapter 8. A proton magnetometer works on that principle and can successfully detect groundwater several meters down by applying an electromagnetic field and measuring the force as the field decays.

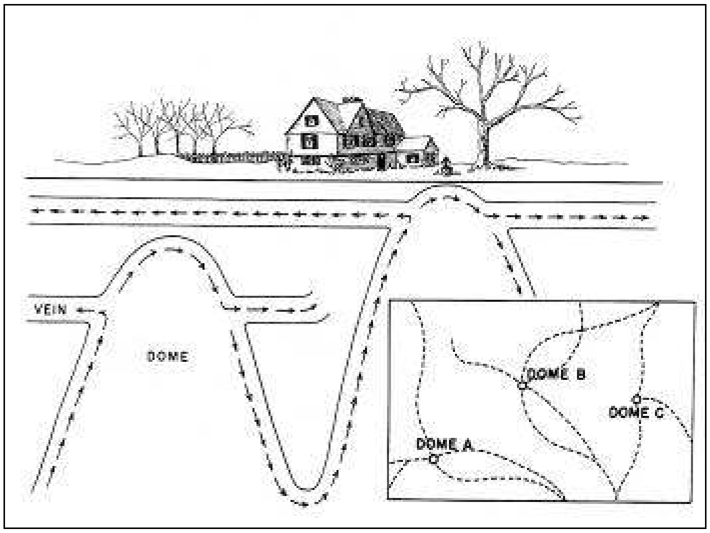
Water in the ground (flowing or not) can conduct electricity, but any electric current in it requires an external source. Galvanic potential can be produced in the ground under certain conditions, and can cause minute currents which will choose the path of least resistance, such as water, but now we're back to established geophysics for which instruments highly more sensitive than our bodies are not able to differentiate water.

Or maybe it's the other way around -- moving water flowing through the earth's magnetic field creates its own electric field, an underground electrical generator, so to speak. The problem here, of course, is that this "wire" is at all points grounded. Very grounded, actually.

But details aside, should an electromagnetic signal indeed emit from water, it would reflect the characteristics of its electromagnetic source, not the liquid. Those characteristics could be AC, DC, direction or polarity, all irrelevant to the water stream.

Let's look at Henry Gross and His Dowsing Rod (1951). The author Kenneth Roberts touts dowsing abilities of a game warden in Biddeford, Maine, the most celebrated dowser of his time.





Roberts maintains that underground water veins bear no relation to the water table. Veins, as illustrated on the right, come from huge "domes" which are pushed up from great depths "by the same sort of pressure that drives up oil." Roberts is inadvertently correct. Petroleum isn't driven upward in oil rivers and water behaves in like manner.

A few excerpts:

> *When the potentialities of the rod are more clearly understood and utilized, it may rank with electricity and atomic power.*
>
> *Why... shouldn't scientists, in addition to spending time, energy and money on questionable laboratory experiments with dowsers devote more of their energies to developing an invaluable, even though mysterious, phenomenon that, properly utilized, would prevent wars, move mountains, turn deserts into lands of plenty, feed the hungry, cure the sick and change the face of the world?*

Not only did Gross claim to trace the winding course of underground rivers, but he also could specify the depth, direction, rate of flow, and potability, implying a signal spectrum of signals, one relating to distance, another to direction, etc. Moreover, he could do it over a map of a place far distant.

Not all readers found Gross' story convincing, however. From "Dowsing Is Nonsense," a review in Harpers Magazine, July 1951, by Thomas Riddick,

> *Mr. Roberts claims that Henry Gross can infallibly locate "veins" of underground water if they exist; that within extremely close tolerances he can determine the depth to, and through, the vein, as well as the rate of flow.*
>
> *It may come as a surprise to both Mr. Roberts and Henry that in many sections of the country there are no "veins" of water. It is situated everywhere underground, and often close to the surface too. A well in one particular spot is not better (nor worse either) than a thousand other locations situated within a half-mile radius.*
>
> *Therefore, for a dowser (with or without a forked stick) to pick out a well location and say "there's water below" is both pointless and meaningless.*
>
> *Henry definitely goes off the beam of any known facts, however, and conjures up a theory of which he has no proof whatsoever, and which is fantastic and contrary to all known science, when as Mr. Roberts says,*

> > *In tracing veins, Henry found that... all of them originated in a single spout of water, rising from deep underground. Henry called this central spout a dome or a pipe of water. These domes, always, are on high land-on mountain slopes, even, rather than in lowlands.*
>
> *Henry's "dome" theory was undoubtedly conjectured by associating water wells with oil wells, where "domes" definitely exist. There is no relationship whatsoever between the two.*
>
> *The source of oil was (and is) the decomposition of organic matter (plant and animal life). The organic matter (now oil) in the Appalachian range was laid down some two hundred million years ago, whereas water is by nature a yearly cyclic occurrence. Mr. Roberts should know this.*

But we needn't hang our hat on Henry.

It is well within the capacity of many creatures to receive electromagnetic signals from the earth. Electroreception is found in lampreys, electric eel, sharks, rays, lungfishes, bichirs, coelacanths, sturgeons, paddlefishes, catfishes, neotropical knifefishes, elephant fishes and the platypus. Magnetoception is observed in birds, where sensing the earth's magnetic field is important to migration, and has as well been observed in fruit flies, honeybees, sea turtles, bacteria, fungi, lobsters, sharks, stingrays, lobsters and crocodiles.

Such mechanisms have eluded discovery in human physiology, but arguably could exist.

And as for the why, could there be a better concession that this?

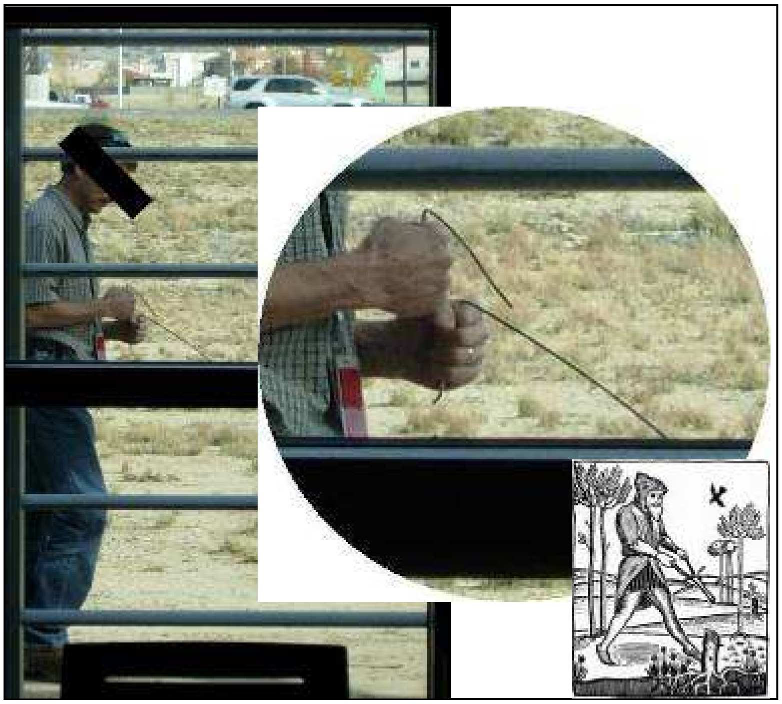
> *I know very well that many scientists consider dowsing as they do astrology, as a type of ancient superstition. According to my conviction this is, however, unjustified. The dowsing rod is a simple instrument which shows the reaction of the human nervous system to certain factors which are unknown to us at this time.* -- Albert Einstein (1879-1955), letter to Herman E. Peisach of South Norwalk, Connecticut, February 16, 1946.

And if it was of interest to Einstein...

Sandia National Laboratories is a $2.2-billion/year facility of the Department of Energy's National Nuclear Security Administration. The lab's primary mission is

> *That of ensuring that the U.S. nuclear arsenal is safe, secure, reliable, and can fully support the nation's deterrence policy.*

For national security concerns, we have obscured the identity of the maintenance employee photographed in November 2009 searching for a suspected water leak at the research facility.



Note that the employee utilizes two bent wires of unequal lengths, the purpose perhaps to estimate the leak depth by triangulation. In the corner is a redrawing of a sixteenth-century woodcut. Back then they didn't have wire coat hangers.

But let us also consider the art of double psychology. Sandia Corp. is run by very smart people who wish us to smirk at the deluded plumber from Facilities. But perhaps -- and for the rest of this we'll need the Rio San Buenaventua's secret tunnel map of Chapter 86 -- he's actually a communications officer from the never-mentioned Liaison Division. We can't reveal more.

So how might dowsing work, assuming an electromagnetic basis?

Electromagnetic Dowsing

Excitation	As the dowser does nothing to the water, the excitation is internal. There have been other opinions, however. Ranskassa de Tristan's Recherches sur Quelques Effluves (1826) hypothesized that a divining rod excites a hydric charge due to its positive right arm and its negative left, similar to a U magnet. To dispute such nonsense, we can review to the purported magnetic sea-to-springflow engine in Chapter 8.
Emission	Water filtering through clay layers might be expected to produce a magnetic gradient on the order of 0.0001 gauss/meter. The expected change in a magnetic field due to an aquifer would be no higher that 0.01 gauss.
Transmission	We will assume that nothing in the intervening strata attenuates this signal.
Reception	Among the ideomotive mechanisms suggested are those in which a dowser bio-electronically senses water's magnetic gradient. As the human body is indeed a complex network of electrical phenomena, it is not out-of-hand to hypothesize that certain humans are hyper-sensitive to such stimuli.
Recognition	As humans are insensitive to magnetic fields of less than 100 gauss, however, no one would seem able to electromagnetically sense an underground river, but who's to say?

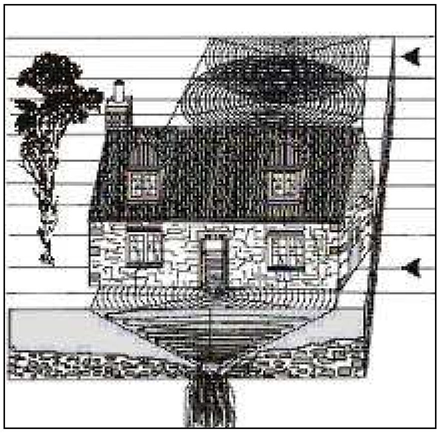
Now we move from detection advocated with scientific vocabulary to an approach founded in what can best be labeled anti-science, that of subtle earth energies. "Subtle" is the key, as they're not "physical." A subtle field is perhaps a vortex composed of two spiraling bands, one positive and the other negative, the former carrying the charge and the latter being neutral. At this point we quit trying to follow the explanation, as it's too subtle.

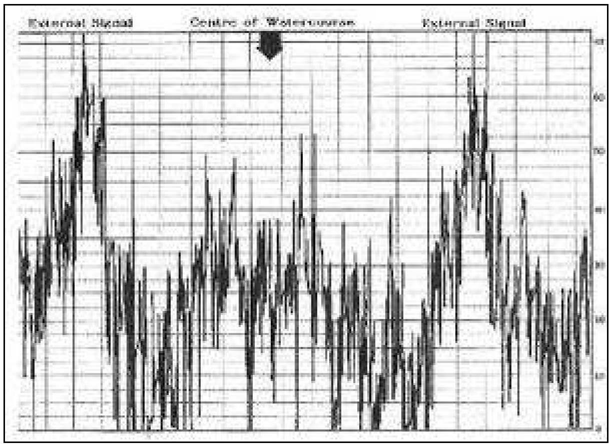
Earth energies are thought to be key to finding artifacts of lost super-human civilizations, healing waters, toxic wastes, harmonic convergences, esoteric truths and much, much more. Finding a mere underground river is a relatively small potato.

As David R. Cowan's internet posting, "Divining and Dowsing, How to use Divining Rods to Find Earth Energies," explains,

> *The plan view reveals three sets of lines running parallel to each other, each of which has three further lines of energy. Guy Underwood called these "water lines."*
>
> *Concentrate on finding an underground stream and you should find the central wave first, directly above the flowing water. Place a marker over this. The rods will also tell you the direction of flow. Then walk on at a right angle to the stream until the rods react again at one of the outer parallels. Here place another marker. The distance between the markers is the same as the depth of the underground water.*
>
> *This is a simplification of the procedure, since there are said to be other wavebands inside and outside of the parallels, also produced by the running water. It is by finding these that experienced water diviners can judge how much water there might be in an underground course.*

The energy field below is proven by the graph, though to actuate recording pens at the "External Signal," the "Centre of Watercourse" and again at the opposite "External Signal," the energy can't be especially "subtle."

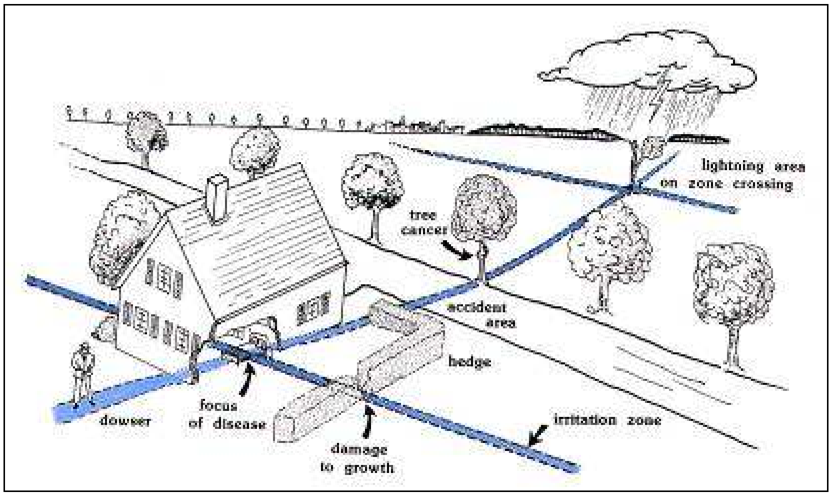




Effects of Harmful Radiation and Noxious Rays (1974) by the American Society of Dowsers extends the earth-energy viewpoint.

> *In addition to disease in humans, animals and plants, it has been observed that auto accidents repeatedly occur at points where veins of underground veins run under roads and highways.*

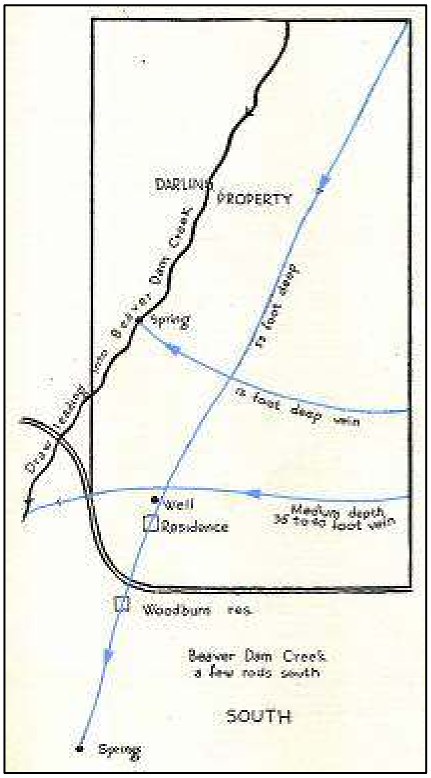
The sketch below, "Various Effects of Underground Water Veins," is redrawn from the same publication.


lightning area on zone crossing
tree cancer
accident area
hedge
focus of disease
dowser
damage to growth
irritation zone

These would be veins of the noxious variety, of course.

While the case for, say, an electromagnetic basis for dowsing invites scientific debate (and thus the opportunity for advancement), a model based on earth-energies spins its proponents out of a meaningful dialogue.

The evidence for dowsing, albeit quasi-scientific or unshakably-subtle, tends to be anecdotal and without experimental control. As in the case below, a dowser tends to be familiar with the landscape and the record of local drilling, rarely does he or she select a geologically-unlikely site, and never are comparative wells drilled at adjacent sites rejected by the dowser.


DARLING PROPERTY
Draw leading into Beaver Dam Creek
Spring
13 foot deep
15 foot deep vein
Well
Residence
Medium depth 35 to 40 foot vein
Woodburn res.
Beaver Dam Creek a few rods south
SOUTH
Spring

The map from What and How About "Water Witching" (1935) by C.C. Hammerly shows divined depths of subterranean streams. In the center, a vein 4 meters below the surface crosses another, 17 meters down. The author, the dowser himself, confirmed the upper of the two by following it, "sounding every few yards," to the spring where his client drew water.

Note that the well, presumably a good one, is sited near such an intersection. The unanswered question -- which came first, pinpointing the subterranean crossing or a well yield "proving" the geometry? As the location is in Oregon's alluvial northern Willamette valley where the water table is wide, yield would likely confirm a vein intersection anywhere on the map.

The author expresses a dim view of the ideomotor concept,

> *Perhaps psychology should not have been mentioned here; and would not have been, except for the fact that some psychologists have discussed the subject with evident failure to grasp the fact that "water witching," strictly speaking, is a physical attribute, and not a psychological one at all.*

In Chapter 31, the chapter about poetry, we deferred discussion of Carl Sandburg. It's Sandburg the historian (well-worded history, to be certain) to whom we now turn. From his Abe Lincoln Grows Up (1925, 1926 and 1928),

> *Even the water underground, the streams and springs, were whimsical, unreliable, ran by luck, it seemed, in southern Indiana. Not far from the Lincolns was a region where rivers dipped down into limestone and faded out of sight. "Lost rivers," they were called. In Wyandotte Cave a walker could go fifteen miles around the inside. In some counties there was no telling when a good well would give out and san, "No more water here."*

To this point, Sandburg's just telling us what we know about karst. Now for the dowsing.

> *Abe's father hired a man to come around with a witch-hazel and tell by the way the magic stick pointed where to dig a well that wouldn't go dry. The well was dug where the witch-hazel said it should be dug. And the well went dry just as others before had on the Lincoln farm.*

That's history, not poetry.

Objective validation doesn't come from finding (or not finding) water, however; it comes from a statistically significant record of both fewer false positives and false negatives.

There is a small body of studies (and like the table before last, in surprising proportion, by Germans) suggesting that some dowsers achieve results better than would be statistically expected, but in much greater abundance are reviews that statistically reject such findings.

We may, however, find more interesting than electrons and such, the question of why we tend to believe in dowsing. Chapter 90, Why Do We Believe What We Believe?, will pursue this in relation to underground rivers as a whole, but we already can sense the kernel of an answer.

Kate Daloz reports a New England case study in "The Dowser Dilemma," American Scholar, March 2009.

> *Instead of pooling in lake-like aquifers, Vermont's groundwater runs through fissures in its solid bedrock, forming underground streams, some as wide as the bed of a pickup truck, others the width of a pencil eraser. The streams may come together or branch off, following the fractures in the stone, or they may run parallel for miles without ever intersecting. A hole drilled straight down from the surface will slice through a number of these, and water will leak down in rivulets, like those dampening highway road cuts and freezing into beards of ice in winter. Another hole, drilled even a few yards away, could pull water from the same fissures, or some of the same, or none at all.*
>
> *For no reason other than chance, a well drilled on the north side of a field might produce clear rich-tasting water, while one on the south side might bring up water that reeks of rotten eggs or leaves rusty streaks on the laundry. The neighbor up the road might lose his water pressure in even the mildest drought, and another family down the road will have tap water the color and flavor of stale tea if there is too much rain. Is it better, then, to drill at the top of this ridge or near that stand of pine? Here behind the garage or there next to the fence line? A wrong choice could mean a lifetime of dribbly, rationed showers and a useless dlishwasher.*

We'll return to Daloz' underground stream description, "some as wide as the bed of a pickup truck, others the width of a pencil eraser" in Chapter 90, Why Do We Believe What We Believe, because of its quantitative explicitness.

The farmer concerned about his or her livestock or the suburbanite concerned about pollution, Daloz notes, finds the notion of underground lakes renewed by underground rivers far more reassuring than geological aquifer parameters. One wants a picture.

And while we're in New England, we must allow ourselves a stopover in Eagle Lake, Maine. From "Mount Desert," Harper's New Monthly Magazine, August 1872,

> *Eagle Lake, a body of fresh-water some mile in width and two or three miles long, is a phenomenon in its way. It is situated between Green and Dog mountains, some fifteen hundred feet above the ocean, witch in direct line, is not much more than half or three-quarters of a mile distant. One can hardly realize the presence of so large a body for fresh-water at such an altitude and on a comparatively small island, and witch is completely surrounded by salt-water.*

> *I put this problem to one of the natives, whose farm-house looks down upon the lake from the side opposite the mountain. He replied, "Well, I guess it rains in." The theory of subterranean channels of water far into the earth and underneath the sea, which here finds outlets, was a little beyond him.*

Yankees don't spout fanciful theories about what they can't see, but they know about rainwater.

The following report from Water Witching U.S.A. (2000) by Evon Z. Vogt and Ray Hyman relates to dowsing (Chapter 46), but is more about directing. If we can't find what we want where we're looking, let's bring it to us.

> *Dwin Gordon, of Portland, Maine, has been engaged in water-proofing basements for nearly a decade. Through his dowsing skill, he affirms that he has found that many basements were constantly wet from water oozing into them from veins 5-1.2 to 6 feet below ground or the same average depth of the basements themselves.*

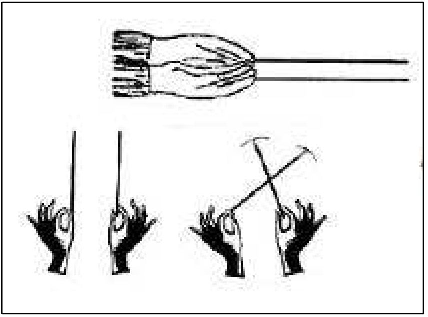
The ropes on the lawn represent edges of an underground vein running toward the foundation of a house in the background. Gordon first pounds a crowbar with T-shaped handle into the earth with a maul. He then strikes the crowbar at ground level. The vein turns at a right angle and begins to flow in the direction of the maul's pounding.

> *Gordon has used his new-found method many times not only to divert water veins around a house basement but also to divert them towards a well gone dry, or to "cut" and turn a vein away from a source of pollution rendering its water impotable.*

We recognize that dowsing is a widely-held traditional practice and it's reasonable that the scientific community evaluates its efficacy. Little evidence shows the art to be significantly successful -- and that that does is not always rigorous -- but more scrutiny's always welcome. We're thus somewhat amazed when we see an uncritically endorsement by a group respected for impartiality. Subsurface Dams :A Simple, Safe and Affordable Technology for Pastoralists, A Manual on Subsurface Dams Construction (2006) by Vétérinaires sans Frontières, Kenya, is a case in point.

> *Dowsing rods (water witching)*
>
> *2 pieces of brazing rods are used to determine wetness of the underground soil. An attraction of ions in an electromagnetic field between water and brass against gravity is the principle behind this process. It is also dependent on talents and gifts of some individuals, but others can learn in a few days of practical training, identifying buried water containing pipes. The best conditions are met a couple of months after rains, when the soils and sand rivers are dry.*
>
> *How to do it:*
>
> *Make a pair of dowsing rods by cutting a full 100 cm length of a brazing rod for gas welding at its middle.*
>
> *Then mark each length at 12 cm from one end and bend them to 90 degrees.*
>
> *Hold the short ends of the two dowsing rods loosely in your hands.*

> *Then let the long ends point forwards and slightly downwards to allow gravity pull the rods parallel to each other.*
>
> *Now walk forwards slowly and quietly.*
>
> *When water or a buried water pipe is underground, the long ends of the rods will be pressed upwards and across each other against the law of gravity.*
>
> *With some people, the rods spread apart rather than crossing.*
>
> *Strong upward pressure on the rods indicates that there is water near the surface.*
>
> *Lower pressure indicates either less water or water being at a deeper depth from the surface.*



> *Should the rods give no response, the reasons may be that there is either no water underground, or the person dowsing has insufficient experience, or lacks the gift of being able to dowse.*

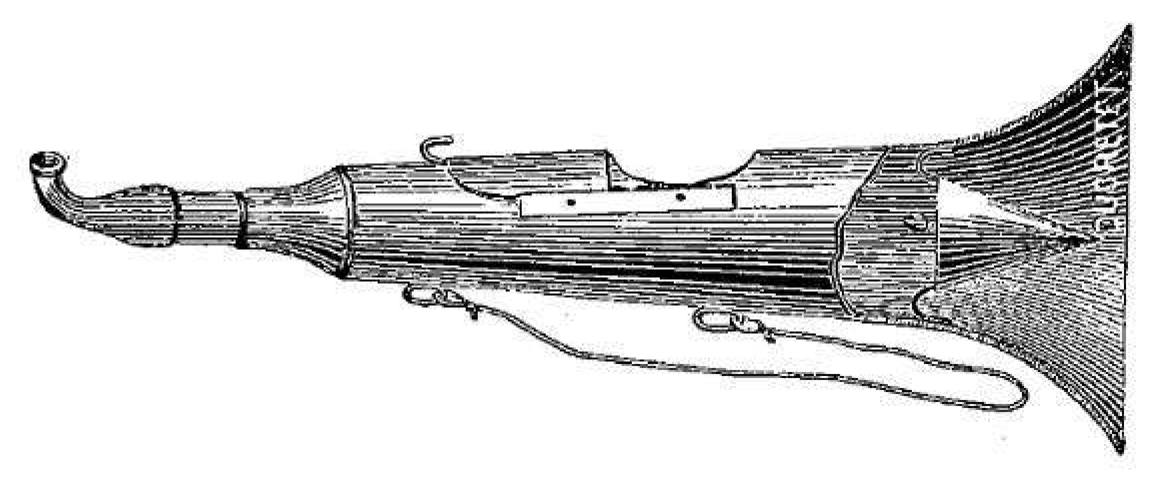
If a remote group wishes to perform such motions, no harm will be done, but an international organization dedicated to bringing modern medicine to those in great need should be more astute.

As Vogt and Hyman point out, dowsing and the theories that underlie it do not persist solely because of a lack of education; they persist because they serve as a guide for action.

Geophysics

Perhaps we're more of the scientific persuasion.

We will begin our survey of detection methods with "Detecting Underground Streams with an Ear Trumpet," Scientific American, April 10, 1909.



> *The apparatus...is based on the principle of the "acoustele" or soud trumpet invented by Daguin and it has now been modified and utilized in the researches for underground water which were made not long since by M. Dienert, engineer of the Paris water supply department.*
>
> *The instrument is surrounded by a box stuffed with sound insulating material to prevent the noise of the outer air blowing against the instrument from being heard.*

> *Inn order to make use of the apparatus under the best conditions it must be properly placed in the ground, and should be set up at the spots which lie at the lowest level. A hole is dug in the ground about 18 inches square and from 10 to 12 inches in depth, and the surface is well flattened so that the acoustele can be fitted tightly upon the ground, and should be placed as plat as possible. The base of the instrument is then sealed with earth to a depth of four inches, but without packing it down. The two tubes are placed in the ears and the observer remains at this position for about five minutes.*
>
> *When it is desired to explore a piece of ground in order to locate an underground spring for the purpose of boring a well, a series of holes of the kind we just mentioned should be dug at different parts of the ground, and the point which is best for carrying out the boring will be the spot which shows the loudest sound.*

The August 9, 1912, Los Angeles Times heralded another underground listening device in "Underground Streams: The Phonendoscope Enables the Hunter to Hear the Flow of the Current of Water,"

> *An ingenious application of the little instrument known as the phonendoscope, which is merely an improved and very sensitive stethoscope, for locating underground streams was described in Himmel und Erde.*

The article then describes the instrument, which we'll do by means of a drawing. A phonendoscope is a stethoscope with a mechanism in the middle to enhance the sound.

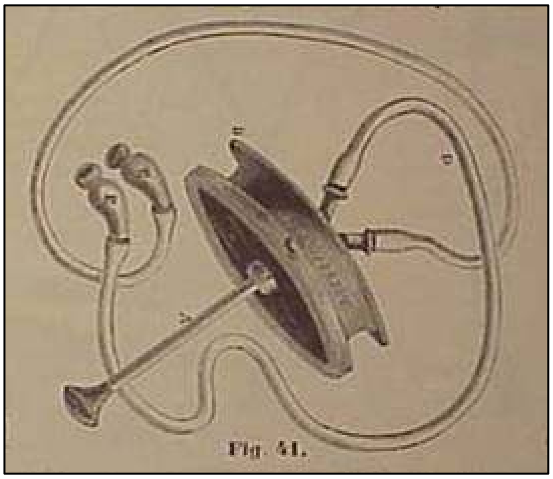


Fig. 41.

> *It occurred to a German scientist, A.R. Koch, that this device might render valuable aid to persons desirous of sinking wells by so intensifying the murmurs of subterranean streams as to render them audible. On a pervious occasion he had happened to be present at the time a well was being dug at a spot where the underground source tapped had sufficient volume and movement to be faintly audible to the unassisted ear, and it was this circumstance which suggested the idea of trying to locate more distant of less noisy currents by the phonendoscope.*
>
> *His experiments were eminently successful. Placing the instrument on the ground, at about ten yards' distance from a spring, a faint murmur of running water was heard, and this sound grew stronger of weaker as the phonendoscope was moved in various directions, the conclusion being unavoidable that the sound was loudest when it was directly above the underground current supplying the spring. Tests were then made on an isolated perk where it was extremely improbable that water would be found. As expected, no sound was heard.*

Or we can perhaps leave the divination to nature. From "Why Lightning Strikes," The Youth Companion, November 19, 1925.

> *Another spot, east of Chattanooga, shows almost a dozen trees struck by lightning, all in a line. Doubtless their roots reach into a subterranean s ream, and the lightning in its work has marked out the course of the hidden stream.*

Today's geophysical groundwater exploration is high-tech business. The difference from dowsing methods is that geophysical techniques are based on explicit scientific theory and for the most part employ active excitation. We'll mention a few technologies and illustrate one method in more detail.

Electromagnetic resistivity methods involve applying voltage to the ground at one location and measuring the response at another. Electrical conductivity (the reciprocal of resistivity) and hydraulic conductivity are not the same, however, the relationship depending on local geology. As with all methods for groundwater geophysical assessment, the investigation benefits from prior hydrogeologic experience.

Metal detectors transmit weak AC magnetic signals to detect a small change in the magnetic field. This has nothing to do with water, however, as water exerts no magnetic response, but we mention it because other attribute greater capabilities to water.

Nuclear Magnetic Resonance (NMR), well-established in medical imaging and crystallography, applies an electromagnetic pulse to atomic nuclei which absorb the energy and radiate it back at a resonance signaling quantum mechanical magnetic properties of the nucleus. The depth of testing is generally measures in centimeters, but the method is claimed to have potential for groundwater detection to a depth of 120 meters. Unlike a metal detector, for which the electronics and housing can be packaged into a hand-held instrument, NMR equipment tends to be room-sized.

Helicopter Electromagnetic (HEM) surveys employ a torpedo-shaped instrument called a "bird" towed below a helicopter. The bird's transmitter emits an electromagnetic signal that interacts with the ground and then is detected by the bird's receiver, revealing information on subsurface electrical properties from which groundwater conditions can be inferred.

A Mexican Navy helicopter dangles a torpedo-like geophysical electromagnetic sensor as if flies in beelines back and forth across the Yucatan peninsula, mapping the karst labyrinth discussed in Chapter 40.

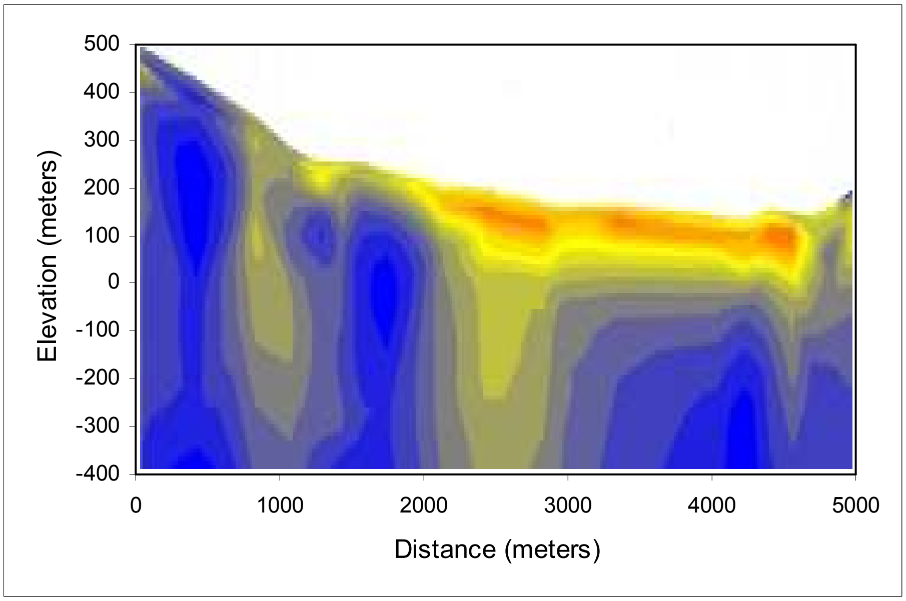
Ground Penetrating Radar (GPR) emits electromagnetic radiation (usually polarized) in the microwave band and detects the reflected signals from subsurface structures having different dielectric constants. GPR sees boundaries, not content. GPR can image a water table having a sharp transition between the water surface and the unsaturated zone, a rare occurrence. Maximum penetration is achieved in ice where the signal can penetrate several hundred meters. In dry sandy soils or massive dry materials such as granite or limestone, the depth can be up to 15 meters.

Controlled-Source Audio Magnetotellurics/Magnetotellurics (CSAMT/MT) is a hybrid magnetotellurics geophysical method that measures both natural and transmitted electromagnetic waves.

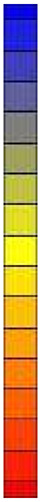
CSAMT/MT

Excitation	An electromagnetic pulse is fired into the ground by a Geometrics StrataGem EH-4 instrument.
Emission	The substrata absorb and re-emit modified electromagnetic waves.
Transmission	The EH-4 works at depths from 10 to 750 meters, depending upon resistivity within the subsurface and signal quality.
Reception	The instrument picks up the electromagnetic response.
Recognition	CSAMT/MT technology measures electromagnetic properties of the geologic strata, not the water. The reading is in turn correlated with local rock samples and the geologist deems which formations are most likely to be aquifers.

Below is an illustrative reading for a cross-section in the Caribbean.



Resistivity in ohm-meters, calibrated to surface measurements, is color coded.



50.0	
38.5	
29.7	Less weathered limestone
22.9	Limestone more water-saturated, more weathered or containing relatively large pore spaces perhaps filled with silts
17.6	
13.6	More competent marl or extremely weathered limestone with considerable silty constituents
10.5	Marl
8.1	Conglomerate matrix, either fine-grained material or volcanic material weathered into clay
6.2	
4.8	
3.7	
2.8	
2.2	
1.7	
1.3	
1.0	

In this example, the zone most likely to contain appreciable and extractable water is the weathered, porous limestone -- but not so decomposed that it's silted shut -- indicated above by the color 🟦.

And there is more to come. As reported on National Public Radio, January 31, 2010,

> *Texting Underground Can Save Lives and Caves*
>
> *Caves are some of the last places on the planet left to explore. Though caving is relatively safe, if something goes wrong deep inside the Earth, a rescue can take days -- in part because cell phones and walkie-talkies don't work underground. But a remarkable teenager in New Mexico has invented a device that may significantly speed that process with the ability to text from underground caves. The young man's invention may have other applications, as well.*
>
> *Alexander Kendrick, 16, won the 2009 International Science Fair for inventing this cave-texting device. The award got the teen from Los Alamos, N.M., a new computer, a trip to Switzerland and $12,000.*
>
> *A cave radio that allows you to beam data to the surface rather than visiting it in person can be extremely valuable.*
>
> *The device is something like a computer attached to a ham radio. It transmits data using low-frequency radio waves that can penetrate rock more easily than high-frequency transmissions, like those in FM broadcasts.*

And here's where underground rivers enter the picture.

> *Now Alexander Kendrick has to fine-tune the radio to make it smaller and tougher and easier for rescue crews to get down into caves.*
>
> *That will have to wait, though, because he's busy working on his 2010 science fair project -- a device that finds underground rivers by measuring their electromagnetic currents*

We'll stay tuned.

Geophysical methods have proven effective in locating subsurface zones where water is likely, but only when a narrow set of environmental conditions is satisfied. Geophysical methods have assisted the appraisal of many aquifers, but have yet to be accurate in the location of underground streams. Such failure isn't difficult to explain -- the technologies lack precision and there in fact are not be many defined streams to discover.

The day may come when we can peer into the ground with enough geophysical resolution to discern water tubes, but until then we'll leave our geophysical search for underground rivers in the style of government-funded research. Further investigation is recommended.

And then, of course, is the possibility that what we find turns out to not there. As reported in "Subterranean Lake in Lancaster," Scientific American, June 15, 1850

> *The Lancaster, (Pa.) Gazette gives an account of an underground body of water, which it says lies beneath the highest point of the city, 27 feet under the surface, and 20 feet above Centre Square. It was first discovered by a workman digging a well, and is thought to be 50 feet wide and 10 feet deep. If flows in a southwestern direction. The Gazette proposes that the water be used to supply the city.*

As the discovery subsequently didn't prove to be discovered, however, the City of Lancaster today draws water from the more-existential Conestoga and Susquehanna Rivers.

Infrared Imaging

The Christian Science Monitor, February 5, 1968, got it wrong with "Finding Underground Rivers."

> *With infrared instruments, man can see down into the earth and detect water flowing underground.*

Men (or women, for that matter) with infrared instruments cannot "see down into the earth," but may ne able to identify where such flow emerges on the surface. Infrared thermography aerial photography uses a thermal-infrared sensor to identify contrasts in radiant thermal energy emitted from earth features. The value of the method in groundwater exploration stems from the fact that emerging groundwater tends to be at a temperature different from that of water already on the surface. Infrared thermography is most effective when weather conditions maximize temperature differences between surface features.

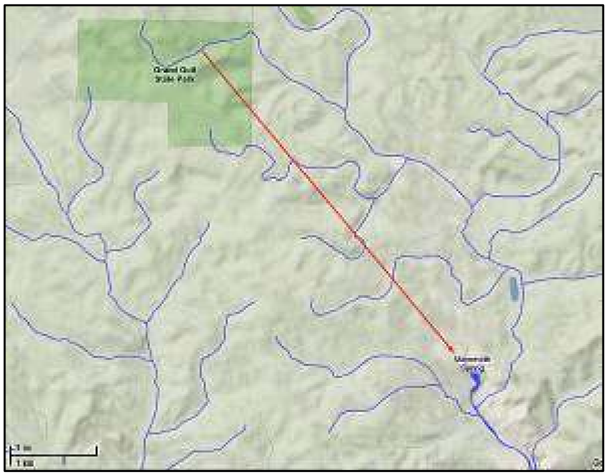
Tracers

If subsurface streamflow can be located, can its path be traced? As noted in Chapter 8, Leonardo da Vinci saw such evidence in chestnut leaves found in Sicilian springs. "Novel Method of Showing the Movement of Subterranean Water," Scribner's Monthly, April 1878, moves us forward another four centuries.

> *Streams of water flowing either on the surface or underground sometimes pass so near each other that one may drain the other, and thus impair its value as a water-power or a source of supply. For this reason it is important to be able to trace the movement of waters that flow underground, and some recent experiments in this direction point out a simple and effective method of determining the path of subterranean streams. The two rivers that were made the subjects of experiment were the Danube and the Aach, the first rising in the Black Forest and flowing easterly; and the second, starting from a powerful spring situated about fourteen and a half kilometers (nine miles) from the Danube, and flowing in a southerly direction into Lake Constance, whence its waters find their way to the Rhine. The bed of the Danube, opposite the head of the Aach, is a friable limestone, much split up and displaced, so that the water finds numerous cracks and fissures through which it escapes underground.*
>
> *It thus became necessary to find out if the water really passed from one river to the other. The first experiment to test the matter consisted in placing 11,000 kilograms of salt in a hole in the bed of the Danube. The water flowing from the spring that supplied the Aach was then examined for salt every hour for several days, and traces of salt were readily obtained. The second and more important experiment depended on the remarkable coloring properties of fluorescein. One part of this substance in twenty thousand parts of water is sufficient to be visible, and forty-five liters (about fifteen gallons) of a solution of fluorescein were placed in one of the openings in the bed of the river. In about sixty hours the spring that feeds the Aach showed a decided green, and this coloring from the fluorescein gradually increased to an intense color that exhibited light green and yellow reflections in the sunlight. The coloring of the water continued for twenty-four hours and then gradually faded away. These experiments*

> *definitely proved the filtration of the water of one river into the other, and they may show a ready method of tracing the movement of underground streams wherever disputes arise concerning the contamination or waste of valuable water supplies.*

Chapter 83, Professor Denton's New England Underground River, notes the use of peppermint as a tracer, but that may have been a one-time endeavor.



Whereas now we know that the waters of Mammoth Spring, Missouri -- not to be confused with Mammoth Cave, Kentucky -- are percolated from diffuse surface sources, early speculation was more interesting.

Stories from the 19th century tell of curiosity-seekers dumping sacks of oats into the draining stream at Grand Gulf to watch the grains emerge at Mammoth Spring, 13 kilometers downstream. Similarly, a hay bale thrown into the Grand Gulf was said to have traveled by underground to Mammoth Spring.

A different opinion regarding the fate of flow from Grand Gulf is expressed in "Grand Gulf Cavern, A Great Cave that is in Southwestern Missouri," News Democrat, December 6, 1900.

> *This cave, containing a subterranean river and lake, had never been explored to the end till the summer of 1885, when Pat Foley, a saloon keeper from Thayer, with a companion performed the exploit.*
>
> *Foley and his companion built a boat of suitable size and hauled in through the narrow entrance... The boat was dragged down to the lake, the touches hastened at the prow and stern, one end of the rope tied to a boulder and the rest of the coil thrown into the boat. When the two men sat down in the frail craft they found the water rose within three inches of the gunwales. It was impossible to use the oars without tipping the boat far enough to sink it, so the men were forced to paddle cautiously with their hands.*
>
> *The water of the lake was ice cold, and at every few dips they had to stop and warm their hands... If the boat were to capsize -- as it was likely to do with the slightest disturbance -- they would be cramped in a minute in the cold water without a chance of help from the outside.*
>
> *As far as people know, cave in the Grand Gulf has no outlet. The Indian notions about the cave are that it is a subterranean waterway much used at one time by boatman, who used to carry provisions in boats to the Arkansas valley. If this be true, the passage must have been stopped up many years ago by some convulsions of nature and the lake formed then.*

Modern (and more manageable) tracers for karst flow include.

1. Solid material in suspension where water flows in large conduits.

   Pieces of paper can be placed in different sink holes and recovered by sieving the flow emerging from springs. (As the method suggests using portions of computer cards, we can guess its era.)

   Dyed club-moss spores transport more readily, but are more difficult to filter out.

   As the laboratory tests are familiar to investigators, fecal coliform have been traced.

   Small time bombs have been used with seismic detection from the surface.

   Baker's yeast.

2. Common salt is cheap and readily measured with a conductivity meter. At concentrations and durations typically used, the salinity is rarely harmful to the ecosystem.

   We may not wish to match the magnitude of the Yorkshire Geological Society's experiment in 1900, however, in which a half a ton of salt dumped into Fell Beck appeared 11 days later at Clapham Beck Head Cave, proving the connection with Gaping Gill. The observation leads to a velocity estimate in then order of 10 meters/hour.

3. As organic dyes are sorptive, they must travel quickly to be detected downstream. Measuring the concentration requires specialized instrumentation (e.g., a field or laboratory fluorometer).

   Rhodamine can be detected at very low concentrations and are thus useful for high flows.

   Aniline is colorless, but it slowly oxidizes to a red-brown tint. It possesses a somewhat-unpleasant odor of rotten fish and is toxic by inhalation of the vapor. Its carcinogenicity, if any, is not known. We're pleased to report it's no longer used.

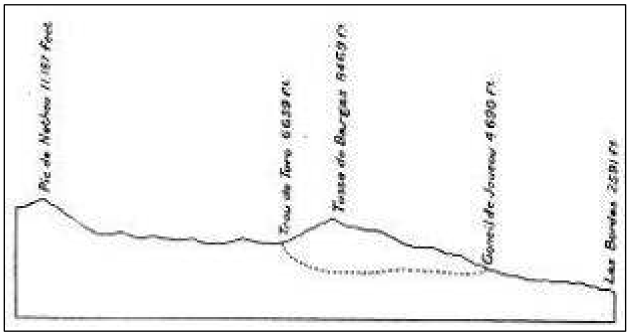
   Fluorescein (also known as Uranine) was the "novel method" of the Scribner's 1878 citation at the start of this section.

   The River Garonne flows from northern Spain to the Atlantic in southwestern France. Glacial meltwater disappears in the headwater sinkhole Forau d'Aigualluts, from where it flows 4 kilometers within Tuca Blanca de Pomèro limestone, resurging 600 meters lower in elevation at Uelhs deth Joèu, "Jove's eyes."

Forau d'Aigualluts

Uelhs deth Joèu

The subterranean route was suggested by Ramond de Carbonnières in 1787. The illustration to the right is from "Submarine Gullies, River Outlets, and Fresh-Water Escapes Beneath the Sea-Level," Geographical Journal, October 1899.



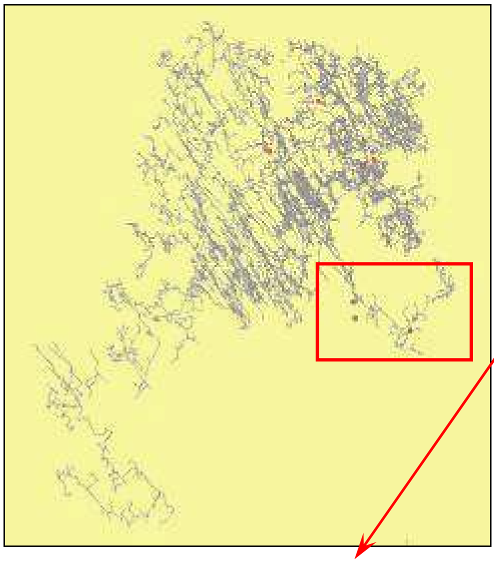
The linkage was not confirmed until 1931, however, when Norbert Casteret poured 55 kilograms of fluorescein into the sinkhole at twilight and noted its emergence before daybreak. We don't know the hour because it was too dark to tell.

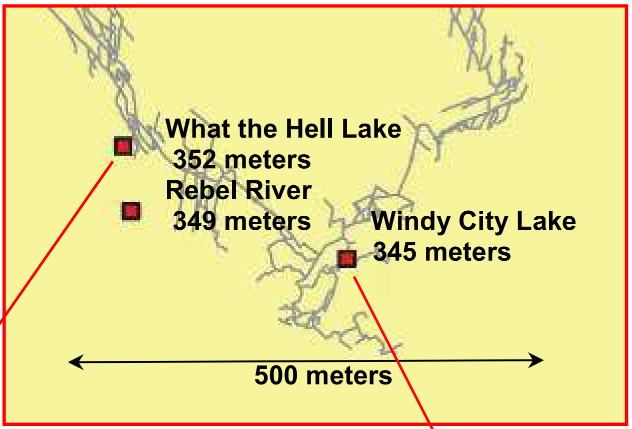
The photo to the right is of Casteret paddling in a Garonne cavern, but not the reach from Forau d'Aigualluts.

While hydrologic measurements are sparse, we've enough data to estimate the conduit geometrics by back-calculation. A 2-cubic meter/second discharge and Casteret's timing, as imprecise as it is, mimic what would occur within a multiple-square-meter frequently constricted pathway, rather than an unobstructed pipe in which the 15-percent slope would whisk the flow more quickly than overnight. We're not surprised at this, as Casteret succeeded with a dye, not a floating object.

Native American stories speak of a "hole that breathes cool air" in the Black Hills of South Dakota. Cowboys came across such a hole in 1881 and began the exploration of what was to become Wind Cave National Park.

Geologists believe that the water to drain from the karst caverns 40 to 50 million years ago. The water level today is about 160 meters below the land surface. The cave pools named "the Lakes," however, should perhaps now be singular, as the several pools have risen some 6 meters in 17 years and have merged into a single waterbody which now must be traversed by inflatable boat. We're visiting Wind Cave to observe some examples of dye tracing.




What the Hell Lake
352 meters
Rebel River
349 meters
Windy City Lake
345 meters
500 meters

Left. Mapped cave passages

Above. Cave lakes and elevations

Four liters of Fluorescein dye injected into What the Hell Lake was detected in Rebel River one month later, and after another month, in Windy City Lake, shown to the right

Right. Rhodamine dye injected into a newly opened sink capturing the entire flow of Highland Creek. A month later, the sink began to collapse and water flowed past.

Below. Fluorescein dye tracing a a swallow hole in the Austrian Alps

Fluorescein is no longer used to dye the Chicago River on St. Patrick's Day. Green vegetable dye is used instead.

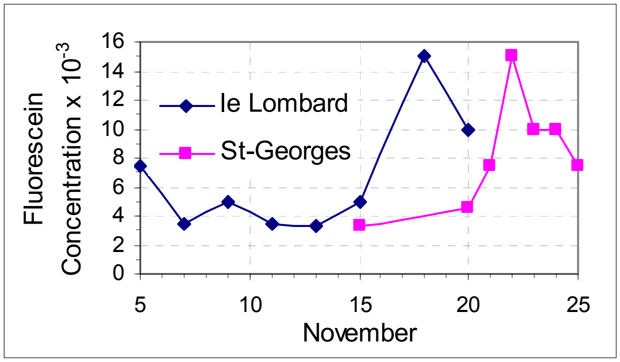
Schwartz (1889) by journalist David Christie Murray provides an example of dye tracing, though the "coloring matter of various sorts" isn't specified.

> *Round and about Janenne* [in Belgium] *the world is hollow. The hills are mere bubbles, and the earth is honeycombed with caverns. By the side of the road which leads to Houssy a river accompanies the traveler's steps, purling and singing, and talking secrets (as shallow pebbly-bedded streams have a way of doing), and on a sudden the traveler misses it. There, before him, is a river bed, wide, white, and stony, but where is the river?*
>
> *The curious traveler, naturally growing more curious than common in the presence of these phenomena, will, at some risk to his neck, descend the bank, and make inquiry into the reason for the disappearance of the stream. He will see nothing to account for it, but he will probably arrive at the conclusion that there are fissures in the river's bed, through which the water falls to feed the subterranean stream, of which he is pretty certain to have heard or read. If he will*

> *walk back a mile... he will see a cavern lipped by the flowing water, and in that cavern, only a foot or so below the level of the open-air stream, he will find its subterranean continuation. It has worked back upon itself in this secret way, by what strange courses no man knows or can guess. But that the stream is the same has been proved by a device at once ingenious and simple. Coloring matter of various sorts has from time to time been thrown into the water at its place of disappearance, and the tinted stream has poured, hours and hours afterwards, through the cavern, which is only a mile away, and stands so near the earlier stream that in times of rain the waters mingle there.*

An aerial photo of the maze-like region is shown below, the terrain today remembered as that of the Battle of the Bulge.

France's Padirac River provides an example of dye tracing.



Proven by dye test in 1948, the Padirac resurfaces 10.9 kilometers to the west at the Fontaine de Saint-Georges, shown above to the right.

"Issue de la Riviere Souterraine de Padirac," Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences (1948) by Guy de Lavaur demonstrated that the underground river travels at 0.032 meters/second.

Marble Arch Cave in Northern Ireland provides another example. Quoting "The Marble Arch Caves, County Fermanagh," Proceedings of the Royal Irish Academy 27, 1908/1909, by Harold Brodrick,

> *In order to test the accuracy of the report that the Monastir stream emerged at Marble Arch, a half pound of flourescein was introduced into the Monastir stream at 11:30 a.m. in dry weather; this was clearly visible in the upper Cradle Hole Cave at 10:45 a.m. on the following day and at*

> *6:45 the same evening, it began to emerge at the Marble Arch spring, having taken thirty-one hours to travel a distance of slightly more than half a mile.*

In SI units, this is 0.008 meters/second or 6900 meters/day.

We'll return to the Padirac and Marble Arch in Chapter 49, Post Charonic Subterranean Boating, as their first paddler was an influential visitor.

Trevor R. Shaw, History of Cave Science, The Exploration and Study of Limestone Caves, to 1900 (1992) tabulates 41 trace tests, 28 of which were in the England, 5 in the Balkans and 8 elsewhere Europe. Two thirds of the total were of 4 kilometers or less and two-thirds of the tests were regarded as successful.

Tracers included "a well-marked duck," a woman's bonnet, "live animals," a shepherd's staff, muddy water (3), red earth, ochre (140 kilograms), floats (3), pieces of bark, wood, husks of oats, chaff or slips of paper (4), straw, oil, "coloring the water," copper sulfate (49 kilograms), sodium chloride (1, 3 and 20 tons) , ammonium sulfate (0.2 and 0.65 tons) , lithium chloride (50 kilograms), ink (130 kilograms), Venetian red (140 kilograms), fluorescein (6), uranin (0.57 kilograms) and flood pulses (3)

Only 11 results included travel times from which velocity could be computed: 220, 1000, 2600, 2800, 4800, 4800 meters/day to peak tracer concentration and 95-145, 140-200, 175-275, 200-320 and 1100-5000 meters/day for tracers reported as a dispersed wave.

Here's a report subequent to Shaw's tally.

Dozmary Pool is where King Arthur is said to have rowed to the Lady of the Lake and received the sword Excalibur. Somewhat more recently, March 3, 1907, to be precise, the Los Angeles Herald said of the pool,

> *It has neither visible outlet nor inlet, but articles thrown into the lake will reappear in Falmouth harbor, which is at least sixty miles away.*

Recovery of "articles thrown into the lake" after a 60-mile sojourn is an order of magnitude more impressive than Shaw's tally. The Herald report may be another Legend of Camelot, however, as Dozmary Pool indeed has both surface inflow and outflow, and in any case, is but 17 kilometers to the sea. What we can best conclude is to be wary of folklore, old and new.

"Pollution of Underground Waters in Limestone," Water Supply Paper 258, USGS (1910) by George Matson reveals the unreliability, in some cases, of velocity estimates based upon tracers.

> *In one test oil, fragments of wood, and common salt ($NaCl^{=}$, sodium chloride) were used in a single underground stream. The materials were put into the stream through an open sink about one-eighth of a mile from its point of emergence in a spring. The oil appeared at the spring in one hour and the salt in seven hours; the wood fragments had not appeared after a lapse of several days.*

Oil	1/8 mile in one hour	8 meters/hour
Salt	1/8 mile in seven hours	1 meter/hour
Wood Fragments	1/8 mile in more several days	< 0.4 meters/hour

Given fortuitious circumstances, underground streams can be mapped by tracers, but as subterranean hydrology is often spatially complex, rarely do tracers reveal a unique and conservative flow path.

The Radio Ball

As the course of subterranean streamflow has challenged electronic wizards for some time, we could have included the next invention in Chapter 46, Finding the Underground Rivers, but we're more impressed with the gizmo aspect.

"Radio Underground River Tracer," Radio News, February 1941, describes a pioneering effort in electrical engineering.

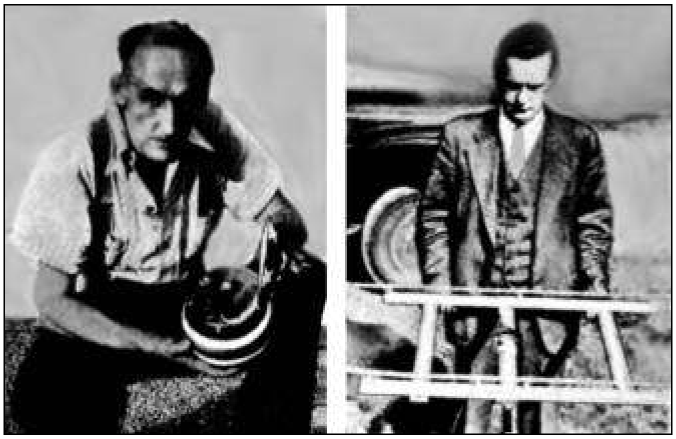
> *A blind Tiffon, Ohio, radio amateur, assisted by a group of enthusiastic fellow "hams," has successfully begun a job by radio which has defied scientists for years -- the tracing of Ohio's famous underground river.*
>
> *Henry J. McFerren used a two-tube ultra-short wave radio transmitter to "see" the underground river never viewed by human eyes.*
>
> *The entire radio set, with battery and the rubber ball in which it rode, weighed only two pounds. McFerren had the ball fabricated especially for the experiment, and carefully placed the set -- batteries in the bottom -- in it and sealed the top. The tiny radio fitted snugly in the eight-inch ball, and a steel antenna, about 18 inches long, extended from' the top of the sphere.*
>
> *McFerren and his aides launched the ball in the seventh level of Seneca Caverns, near Bellevue, Ohio, after several months of preliminary tests by the inventor convinced him that the little set was capable of sending a signal up to 30 miles through the earth's crust.*

Note of the location, Bellevue, Ohio, the subject of Chapter 75, Mainlining the Sewage.

> *It was not the first time that objects had been launched in the river in an attempt to trace its course.*
>
> *Sealed bottles had been dropped into the Bellevue underground stream on a number of occasions-but they never showed up anywhere, far as is known.*
>
> *The Ohio Board of Health, seeking the source of typhoid fever, put quantities of aniline dye in the stream, but no traces ever appeared in any surface stream.*
>
> *The most popular theory is that the stream, which runs under the city of Bellevue, finally comes up at the Blue Hole, a remarkable natural wonder near Castalia, Ohio.*
>
> *The principal direction finder was a home made goniometer.*

A new word every day -- an English teacher's motto. The term goniometry is derived from the Greek words, "gonia," meaning angle, and "metron," meaning measure. Apparently Radio News readers knew such things.

> *This consisted of two aluminum rods, each one wavelength long. The rods were placed on a frame in parallel positions one quarter of a wavelength apart.*

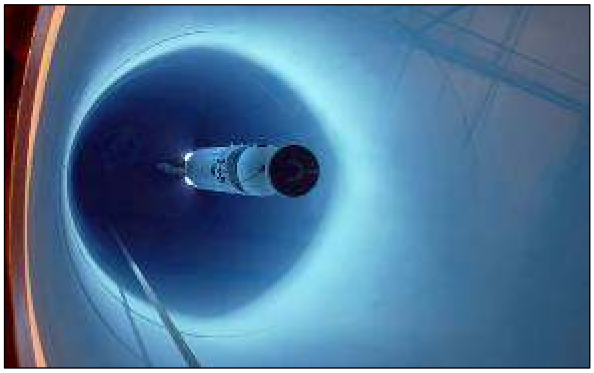


The rubber ball tracer and the goniometer.

> *The ball was launched and McFerren and the amateurs succeeded in picking up a strong tone. Bearings were taken every five minutes, and the direction was seen to change five or 10 degrees with each bearing.*
>
> *After some time, the signal appeared to weaken and be interrupted, and this was attributed to a possible lowering of the cavern's ceiling, which would, of course, partially submerge the steel antenna, thus interrupting the signal. Weakening of the signal was blamed on the brushing of the antenna against the damp walls of the cave.*
>
> *After about three-quarters of an hour the signal stopped and the operators listened In vain for the tone. After a wait of almost an hour, the signal came in again. McFerren and his assistants took a bearing and, wasting no time, loaded the equipment into an automobile and started in the indicated direction -- toward distant Lake Erie and the Blue Hole.*
>
> *They took another bearing and from the cross-references determined that the ball must have stopped at a point 1.1 miles from the starting point. Later the signal stopped and did not again appear.*
>
> *Results of the test, while not conclusive, seem to indicate that the belief that the underground river comes up at Castalia is sound, although what becomes of objects dropped in the cavern has not been explained.*
>
> *McFerren would like to put a small microphone in the next rubber ball he launches. The mike, he believes, would pick up noises in the cavern and indicate the nature of the bed and the size of the passages. He also will use more power on the transmitter.*

We find no record of subsequent attempts, however.

Inspection Vehicles

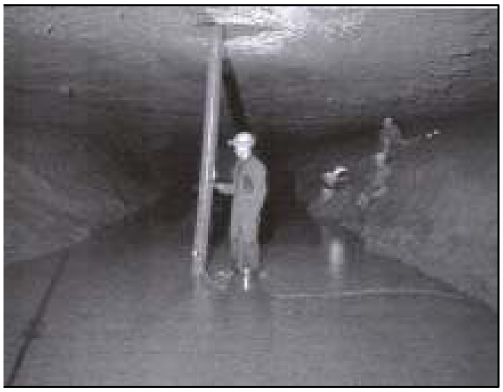


A self-propelled, self navigated torpedo was constructed by Woods Hole Oceanographic Institution to assess the leakage -- as much 1.6 cubic meters/second, some 6 percent of the total flow -- from the Rondout-West Branch portion of New York City's Delaware Aqueduct (Chapter 81, East Side, West Side, All Around the Town). The robot took 14 hours to travel down 75 kilometers of the tunnel, taking a set of photographs every 2.6 meters.

Gaging

And once found, measurement follows.

Stream gage,Logsdon River, a karst conduit within the Turnhole Spring Groundwater Basin, Mammoth Cave National Park



One can travel the conduit for nearly 10 kilometers before ending in a sump at either end, making Logsdon River one of the longest continuously-traversable river passages in the world.

Two hundred meters of Logsdon's length are up to 15 meters below the water table and the remainder is at the water table. The conduit is elliptical in shape, its width, 2 to 10 meters, with a height/width ratio between 0.3 and 3.

In a single storm event, the stage rose 24.6 meters within 14 hours.

CHAPTER 47

WRECKS OF ANCIENT LIFE

From a letter of Charles Darwin to Charles Lyell, January 10, 1860,

> *Amongst the blind insects of the caves in distant parts of the world there are some of the same genus, and yet the genus is not found out of the caves or living in the free world. I have little doubt that, like the fish Amblyopsis, and like Proteus in Europe, these insects are "wrecks of ancient life," or "living fossils," saved from competition and extermination.*
>
> *Farewell, yours affectionately, C. Darwin*

This chapter and the next, Diversity in Darkness, Texan Ecology, are both about biology, but this one is scoping, while the next is a case study of the aquatic community dwells under the Alamo.

To begin this chapter, let us turn to Charles Darwin's The Voyage of the Beagle (1860)

> *Well may we affirm that every part of the world is habitable! Whether lakes of brine, or those subterranean ones hidden beneath volcanic mountains -- warm mineral springs -- the wide expanse and depths of the ocean -- the upper regions of the atmosphere, and even the surface of perpetual snow -- all support organic beings.*

And there we have it from utmost authority: life exists in even the earth's subterranean waters. Thus when wading an underground waterway, we must guard our toes from the inhabitants.

Cavefish

Evolved from their aboveground counterparts, cavefish lack pigmentation, have vestigial eyes (if eyes at all) and possess subcutaneous sensors that enable them to skirt obstacles and detect the vibrations of potential prey. Cavefish range in length up to 11 centimeters in length. All 80 species of cavefish are found in caves having incoming streamflow, as their sustenance is ultimately derived from above.

We'll begin by noting how the discovery of cavefish was covered by the American press, discuss a few biological particulars of American varieties and bring ourselves up to date regarding current ecological concerns.

From "Peculiarities of the Mississippi," American Journal of Science and Arts, January 1833, by Benjamin Silliman

> *Subterranean passages, made by incessant infiltration, producing small holes or excavations which communicate with the interior of the earth, where they meet with subterranean rivers unquestionably exist. As a proof of this fact, we find occasionally that their inhabitants leave those dreary regions, and by pursuing the streams, find their way to the surface of the earth. In what other way can we account for the appearance of fish in ponds, whose waters are clear, and whose depth is sufficient to keep cool through summer, and of a regular temperature during winter. Fish find their way into ponds in the course of one or two years; where they continue to improve in size*
>
> *We witnessed a very remarkable fact of this kind, in the case of a fish which visited the surface, a few years ago. The passage which enabled him to reach the light of the sun was connected with a hole at the bottom of a ditch, of about three feet in diameter, and two feet deep. This canal was made to drain a small valley, of rain water; during the winter and spring seasons, the water rose quite as high as the bottom of the canal; but did not during summer approach nearer the surface than twelve or fifteen feet. This fish was about eight inches in length, and perhaps of equal circumference. The hole occupied was filled with water, and there was not a sufficient quantity in the canal to enable him to pass up or down the valley/... He would sometimes be*

> *absent for two or three days in succession. After a stay of about three weeks, and not being able to find a large stream, or a fit habitation on the earth, he disappeared.*

The Auburn Daily Bulletin, March 25 1872, reported the discovery of a cave in south central Indiana, at a depth of 20 meters having,

> *A beautiful river of clear water, which, upon examination, was found to contain an innumerable number of small white fish.*
>
> *As an experiment, a lighted candle was placed upon a small piece of plank and set afloat. It started off into the darkness with the current, and was lost to sight. Several persons have visited this great curiosity, and many were the conjectures as to where the water came from and whither it went, but nothing satisfactory could be arrived at.*

We'll explore in Chapter 78 how the presence of certain fish species led to assumptions of subterranean Great Lakes connections. Here, we'll just cite the New York Sun, October 18, 1903, "Fishing in Far Wilds, Almost and Lure Serves in Newfoundland," a story of like logic to introduce the perplexity of seemingly-out-of-place fishes.

> *The strangely marked trout were not alone in the lake... Three or four grilse, or young salmon, of two or three pounds were also caught, which led to much discussion among the members of the party. There was no visible connection with the sea, though the guides asserted that the effect of the tides was clearly visible twice a day, and that the salmon must have come in my some underground river. The anglers, however, incline to believe that they were so-called land locked salmon, or ouananiche, but have no argument of offset the appeal to the intense brilliancy of the red coloring of their flesh, in proof that they were newly run from a deep sea feeding ground.*

Or from far to the south, "The Switzerland of South America," The Independent, October 10, 1907, a report regarding Lake Titicaca,

> *This great lake, tho it receives the waters of twenty rivers, has but one outlet, the sluggish Desaguardo River, thru which part of its waters flow into Lake Poopo, another very large body of water, that lies at a somewhat lower level. But where do the waters go then? No one can tell, for Poopo has apparently no outlet. Probably an underground river carries off the surplus waters of both lakes into the Pacific, 300 miles away, for it is said that a certain kind of small fish found in Lake Titicaca and Lake Poopo are also found in the ocean opposite these highland seas, and nowhere else.*

Our immediate interest, however, isn't that of migratory routes, but with fish that seem in themselves to be fundamentally peculiar.

In Pictorial Guide to the Mammoth Cave, Kentucky (1851), Horace Martin cites a bit of ichthyology.

> *In that river and the others which are found in the Mammoth Cave, that very extraordinary fish, the White Eyeless, are to be seen. On the occasion of our last visit to the Cave, we were shown two of them... Indeed, it has been asserted by men most celebrated in their profession, that these fish are not only without eyes, but also exhibit other anomalies in their organization, highly interesting to Naturalists. At the time the rivers of the Mammoth Cave were first crossed (1840), and since, several endeavors were and have been made to discover whence the White Eyeless fish come, and, also, whither they go; but though various conjectures have been formed, nothing that can be looked upon as satisfactory has been arrived at. All is still mystery, and we suppose will continue so until the end of time.*

Actually, from whence come the White Eyeless fish and whither they go isn't a much of a mystery. Amblyopsidae, or cavefish, of which there are more than 60 varieties, lack functional eyes and pigmentation. Few species exceed 10 cm in length. Some species have tactile organs arranged over the body, head and tail. Cavefish are thought to navigate by means of lateral filaments sensitive to water pressure or by bouncing acoustic waves off surrounding objects. Cavefish have no predators, except in some instances, themselves.

From The Galaxy, July 1875,

> *Mr. F.W. Putnah of the Kentucky survey has made important additions to our knowledge of the fauna of Mammoth Cave. He procured four species of fishes which are identical with those in Green River, proving that the river fish enter the subterranean stream. Thus he found fishes of a dark color and perfect sight in the same waters that nourish -- the white, eyeless fishes. The latter were found in one stream in a position that proved that they could pass into the daylight if they chose.*

From the Indian Journal, Muskogee, Oklahoma, June 9, 1881, "Life in an Underground River -- Blind Fish,"

> *An interesting exhibition of blind animals was recently given to a party of visitors by a gentleman living in the vicinity of Mammoth Cave. The cave, as well as many others, has its subterranean rivers and lakes that are stocked with a fauna peculiarly their own, and the observations that have resulted in our present knowledge of it are of particular interest. Years ago the fishes undoubtedly entered the underground river, and gradually from disuse, as generation succeeded generation, their organs of sight have almost disappeared -- the result of inactivity. In the young the eye is more prefect, but as the fish grows, its optic nerve remains intact of gradually dwindles away, so that the most careful scrutiny often fails to reveal it in adult forms. The eye itself becomes covered with a white membrane, probably a fatty substance, and has the vacant stare of a boiled cod. The fish that was originally a minnow assumes a pale and ghostly appearance, and when observed under a glaring torch darting about in the inky water strikes the beholder as in strict keeping with the surroundings, which are, to say the least, grim, ghostly and peculiar. To observe the fishes and capture them, almost perfect silence must be maintained, and the white forms will soon be seen darting to the top of the water and as quickly retreating to the cover of some adjacent ledge. Bits of bread or flies thrown into the water, however, attract them, and if a net is dexterously used, the game can be secured.*

"The vacant stare of a boiled cod" we consider one of the better lines of journalism, ever.

In reporting on the discovery of 1 to 2-centimeter fish in a 75-meter well in the Mexican desert, L'Abeille de la Nouvelle-Orleans, February 2, 1906, saw little reason to doubt the existence of larger specimens.

> *That the larger fish did not come up the pipe does not mean that there are not larger ones in the channel beneath. In the first place, the pipe or the well is comparatively small in diameter, and again the well may have struck near the bank of the underground stream, or the shallow water part, where tiny fish are accustomed to congregate.*

From "Blind Fish Found in Indiana," Urbana Daily Courier, February 7, 1918,

> *In these days of fish stories, if some one from "down Indian way" springs us one about the blind fish of Mitchell and Lost River, don't set him down as a falsifier... No less a person than Dr. Carl H. Eigenmann, dean of the graduate school of Indiana University... has made public some of his researches in the Lost River section of Indiana...*
>
> *The Lost River region in Lawrence and Orange counties is drained almost entirely by subterranean streams. The terrace water reaches these streams through sink holes by which the entire region is marked. One of the particularities of the country is that some of the underground rivers flow north and escape from caves along the White River valley, while others tend to then south and come to the surface as large springs, one of those forming Lost River at Orange.*
>
> *Shawnee cave, three miles east of Mitchell, Ind., furnishes one of the most beautiful of these streams. A good sized river comes boiling forth from the mouth of the cave at the head of a deep ravine. This stream has been followed underground for nearly two miles...*
>
> *It is in this stream that Professor Eigenmann discovered his blind fishes...*

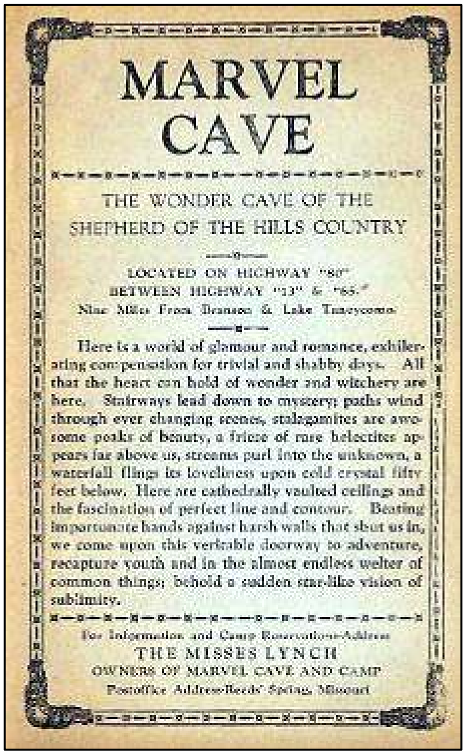
> *"During the first few hours of their development the eyes start in a normal was. The unusual environment, however, causes the eyes to lag in their development and shortly after to begin to degenerate. By the time the fish reach middle age there is nothing left resembling an eye and by the time the fish reach old age almost every fragment of the eye has been cleared away. The blind fish feed on crawfish and shrimplike creatures which they detect by the profusely developed tough organs about the head."*

The January 30, 1917, edition of that same paper featured a story from Missouri, "Marble Cave is Explored, Believed to be as Large as Famous Mammoth of Kentucky -- Fish and Salamanders in It."

> *The big lake which has lately been discovered in the cave, deep down in the bowels of the earth in the very bottom of the big opening was located while the party was exploring the underground river which runs through one of the main corridors... In many respects the river resembles a surface stream. If flows over a rock bottom and has a swift current... It is not wide and if it were a surface stream it would not be classed as a river but as a creek. It varies in width from 20 to 40 feet. In many places it is shallow and full of shoals, over which the water dashes, throwing a white spray into the air. In other places large pools have formed that flow slowly and are of great depth, in which are many fish native to this section of the country, which are all blind. White salamander, a species of the lizard family, crawl along the slimy edges. These creatures are native only to this cave, the only ones ever been discovered having been found here. Like the fish in the river, they are also blind.*

Marble Cave became Marvel Cave in 1927 for marketing reasons and it's now part of Branson's Silver Dollar City Theme Park. The brochure's from the 1930s.

Lantern Tour
$10.00



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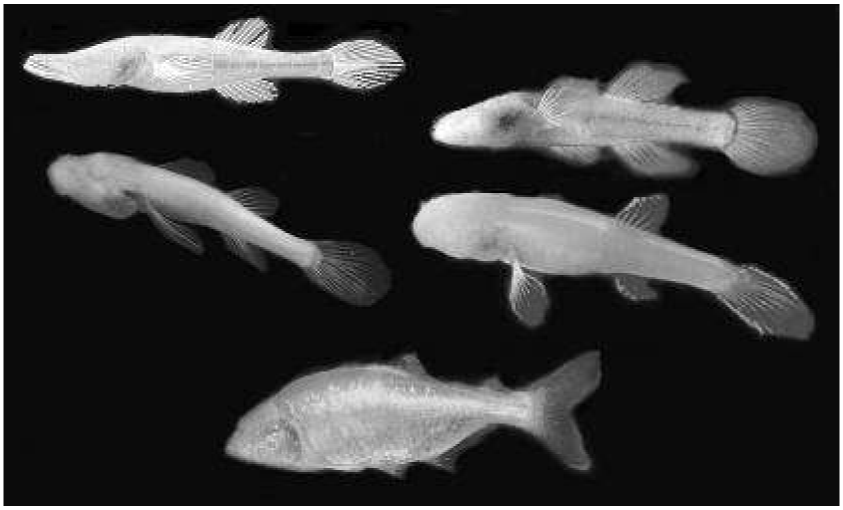
OWNERS OF MARVEL CAVE AND CAMP
Postoffice Address—Reeds' Spring, Missouri

"Eros" by Chard DeNiord in The American Poetry Review, September 2007, extols the resilience of such creatures.

> *He rules in exile like a king who hides in public and writes nothing down.*
> *He replenishes his sources from an underground river that is the home of the most hardy fishes.*

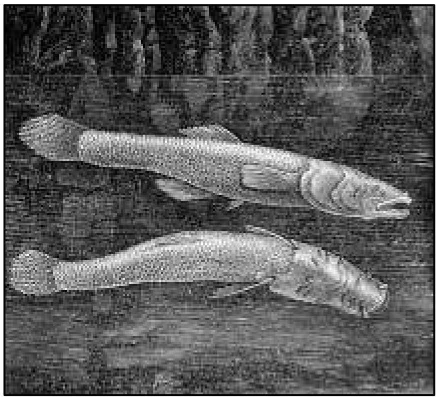
Given the publication, we'll allow DeNiord poetic license, but far from being "most hardy," many cavefish are on the verge of extinction.

Shown below are five of the species found in North America.



Alabama cavefish (endangered) Southern cavefish
Northern cavefish Ozark cavefish (endangered)
Mexican tetra

The Alabama cavefish feeds on copepods, isopods, amphipods, and other small cavefish. The Southern savefish diet includes copepods, other microcrustaceans, crayfish, and trichopteran and dipteran larvae. The Northern cavefish feeds on benthic crustaceans and worms but can live for two years without food because of their low metabolic rate. Stomachs of Ozark cavefish have been found to contain copepods, small salamanders, crayfish, isopods, amphipods and young of their own species.



Blind fish as seen in the children's book Round-About Rambles in Lands of Fact and Fancy (1872), Frank Richard Stockton

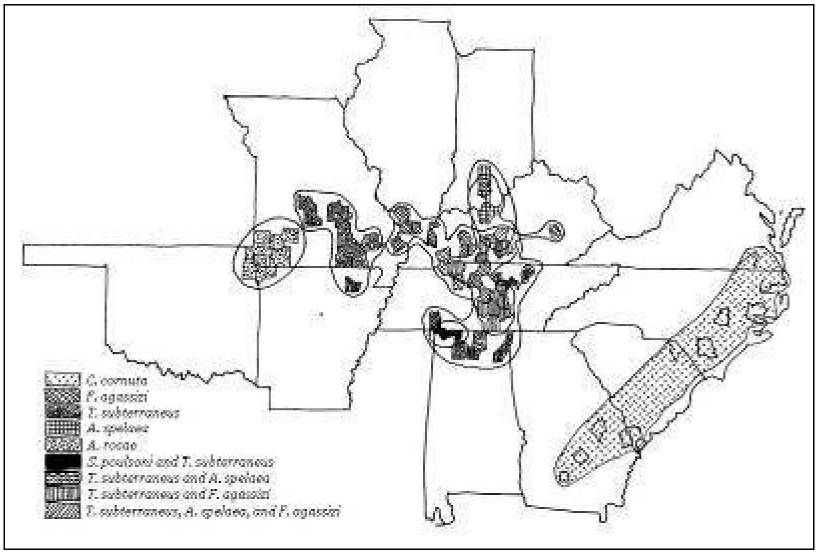
The story in the January 7, 1940, New York Times is a peculiar one.

> *Well Yields Eyeless Fish*
>
> *Cureall, Mo. -- Transparent fish without eyes are being pumped from a well on an Ozark farm near here. Harrison Garrett, owner of the farm, said the strange fish were discovered several years ago, soon after the well was drilled. They were two to five inches long and live only a few hours on the surface although left in water. They resemble catfish. Their bones are visible in the sunlight. The well is 100 feet deep and a driller said the water supply comes from an underground stream six feet deep.*

Research indicates no geographically-likely cave fish that grow to 12 centimeters in length and cave fish in all cases dwell near cave entrances where nutrients wash in, not in solution channels that might be intercepted by well boring. Another underground river mystery, we have here, a biological one in this case.

The Mexican tetra can be found in the lower Rio Grande, Neueces and Pecos Rivers in Texas and from central and eastern Mexico to Panama. Mexican tetras can more easily be found in pet stores for $2.00.

The map shows the habitat of cavefish found in the southeastern United States.


C. cornuta
F. agassizi
T. subterraneus
A. spelaea
A. rosae
S. poulsoni and T. subterraneus
T. subterraneus and A. spelaea
T. subterraneus and F. agassizi
T. subterraneus, A. spelaea, and F. agassizi

Note the name is "cavefish." It's not "underground river fish." As their nutrition is that which enters the cave, cavefish prosper below inlets. Surface flooding occasionally washes cavefish out of cave entrances, but there are no reports of upstream cavefish emerging from downstream springs.

As to why several of the species are endangered, note the following report from the Reading Eagle, May 29, 1881.

> *Blind Animals. Life in Underground Rivers -- Blind Fish in a Lively Chase.*
>
> *An interesting exhibition of blind animals was recently given to a party of visitors by a gentleman living in the vicinity of Mammoth Cave, and some of the experiments were remarkable in this way. The cave, as well as many others, has subterranean rivers and lakes that are stocked with a fauna peculiarly their own... Years ago the fishes undoubtedly entered the underground river, and gradually from disuse, as generation succeeded generation, their organs of sight have almost disappeared -- the result of inactivity... The largest specimen of this fish captured in late years is said to have been taken during the summer of 1871, and sold for ten dollars to a person who as so desirous of securing the precious morsel that he had it cooked for his dinner.*

Not all that's reported is true, as evidenced by "Eyeless Fish that Live in Hot Water," Mckean County Miner, Smethport, Pennsylvania, March 16, 1876

> *The most singular discovery was made in the Savage mine, Colorado. This is the finding of living fish in the water now flooding both the Savage and Hale and Norcross mines. The fishes are eyeless, and only about three or four inches in length. They are bright red in color.*
>
> *The temperature of the water in which they are found is 128 degrees Fahrenheit -- almost scalding hot... The water by which the mines are flooded broke in at depths of 2,200 feet... It rose in the mine to a height of four hundred feet... This would seem to prove that a great subterranean reservoir or lake has been tapped, and from this lake doubtless came the fish which were hoisted from the mine.*

Thermophilic fish are indeed known to science. The ladyfish (Elops saurus), common off the Carolinas, can survive in water temperatures as high as 95 degrees F. Doctor fish, members of the Cyprinidae family, are found in mineral-rich Turkish hot springs of similar temperature. No fish, however, are known to survive in pools as hot as that reported by the Mckean County Miner.

Analogy to sightless fish was not lost to the philosophers of the era. From St. George and St. Michael (1876) by George MacDonald,

> *The memory that forsakes the sunlight, like the fishes in the underground river, loses its eyes; the cloud of its grief carries no rainbow; behind the veil of its twin-future burns no lamp fringing its edges with the light of hope. I can better, however, understand the hopelessness of the hopeless than their calmness along with it. Surely they must be upheld by the presence within them of that very immortality, against whose aurora they shut to their doors, then mourn as if there were no such thing.*

Not all subterranean streams need be of woeful ichthyologic consequence, however, as illustrated by "Tarpon Fishing, An Exciting Night on Crystal River, Florida," Weekly Age, February-20, 1889.

> *The night was pitchy dark, but the lurid glare from the blazing pine lit up the darkness, and at the captain's order Mr. Black started his engines, and we moved swiftly on over the beautiful bay, steering directly for Tarpon Springs, where an underground river of unfathomable depth rolls its liquid wealth to the water's surface.*

But there is hope for the sightless creatures, or at least there was a century ago, to wit, "Teaching Blind Fish to See," Niagara Falls Gazette, September 7, 1905

> *In the hope of teaching blind fish to see, some interesting experiments are being carried out at the New York aquarium. A large consignment of blind fish has been received there from the Mammoth cave of Kentucky, and Mr. Spencer, director of the aquarium fish hatchery, expects that under his care, the blind fish will in time evolve eyes and see like other fish. The fish are natives of the Echo River, the deepest subterranean stream in the world.*

If one looks for divine providence, "Forrester's Evenings at Home" in Boys' and Girls' Magazine and Fireside Companion, December 1, 1849, presents a children's chat with the instructional Mr. Forrester. We quote but a small portion, though even that much may seem intolerably long.

M.F.: *So, with your permission, we will converse a little while about those great natural veins of the earth. But what are rivers?*

George: *Streams of water, running along the surface of the earth, in natural channels.*

M.F.: *A very excellent definition. Rivers may be large or small, according to the extent of country which they drain. A very small stream is generally called a brook, but it is merely a small river. Rivers, for the most part, rise in high lands, from springs or the melting of ice and snow. When the fall of water is gentle, it is called a rivulet; when violent, a torrent. As it courses along, other small streams fall into it, and thus it keeps constantly increasing in size until it falls into the sea or ocean. Every ridge of mountains and high lands, running through a continent or country, gives rise so numerous rivers. On each side, they pour forth streams of water, which wind through the valleys, refreshing vegetation, propelling machinery, and furnishing a sort of highway for boats; and, having performed their destiny, discharge themselves into the ocean...*

Henry: *I have heard of underground rivers, but I suppose there is no such thing.*

M.F.: *Certainly there are many underground streams, one of which I have seen. I was travelling along in the stage, some years ago, in Kentucky, near the line of Tennessee, when all at once a river appeared bursting out from the side of a mountain. We followed the stream for some distance, and I saw several small mills carried by the water. Presently the water fell into a sort of pit in the rocks, and was entirely lost from sight.*

Flora: *Why, Mr. Forrester, where does the water go to? I should think that the pit would be filled up.*

M.F.: *Perhaps it has no bottom to it. I will warrant you that the water finds the ocean in some way. Kentucky is a queer state in this respect. There are several caves and deep chasms in the rocks within her borders, and the sound of water can frequently be heard in them. The great Mammoth cave has been explored more than three miles under ground. At this point one of these under· ground rivers runs directly across the path. It is a stream of respectable size, and it here falls over a precipice -- I dare not say how deep -- but it must be a great ways. The roar of the water below is distant, yet the air around seems to be shaken by the fall. Who can tell how much longer this cave is? Perhaps it may, at some future day, be explored a great distance further. But there is yet something wonderful in regard to this cave to tell you. In the water above spoken of there are a multitude of fish without eyes. When I first learned this, I confess that my belief was staggered. But I cannot doubt now that such is the fact. They not only have no eyes, but there are not any of the optical nerves in the head, usually found connecting the eye with the brain. Here we have a striking instance of the wisdom of our Creator. These fish have no use for eyes. They are shut up in a dark dungeon, away from the light forever. Yet it is just as difficult to catch these fish as though they had the best of eyes... Wonderful as this is, plainly as the hand of an all-wise Providence is here displayed; it is but one page from the great book of Nature. Look around you where you will, and God is written everywhere. Not only in these little fishes, created without eyes, because they are placed where the light of day never penetrates, but everywhere, in the forest, in the fields, in the seasons, winter and summer, light and darkness, on the shores of the great ocean, and by the side of the rippling brook, everything we examine has its story to tell of the bounty and goodness of our Creator... I am sure you will think it the greatest wonder of all, that a reasoning human creature should reject these proofs of a kind Providence, as inconclusive and visionary. Next month I will tell you something about VOLCANOES.*

Why George, Henry and Flora don't expire of boredom isn't explained, but clearly Mr. Forrester is enjoying his evening at home.

We'd rather just go fishing, preferably where we don't even have to bait a hook. From the Birmingham Weekly Age, May 10, 1893,

> *During the heavy rains of last week a spring appeared on the Pauik place, which is remarkable not only for the suddenness of its coming, but from the fact that there are more fish in it than water. The spring is small, and issues from the ground through a small opening which the water made. Through this hole, and apparently from the bowels of the earth, come innumerable perch of fair size. The fish come in such numbers that they completely fish the spring, and many are forced out of the water to the ground, where they wiggle and die. Parties in the neighborhood have gathered bushels of perch from the spring, but the supply does not diminish. Where the fish come from is a mystery. It has been suggested that a subterranean stream flows near the surface of the ground at that point, and finds outlet through the spring. If that is the case, the underground river or creek is certainly well supplied with fish.*

We'll see in chapters following the role fish played in the deductive discoveries of subterranean river under the Sahara Desert, under the Great Lakes and under the Mississippi. Or should we perhaps say, the role that such fish played in deductive errors?

Crustaceans

The Alabama cave shrimp dwells in just two cave systems in Madison County, Alabama, one of which is within the U.S. Army's Redstone Arsenal. The creature may be harmless, but watch out for the cave crabs.

All the Year Round was a Victorian magazine founded and owned by Charles Dickens. Here's an item from August 6, 1864.

> *The man who is curious in crabs and lobsters should raise the ghost of Doctor Philip Sachs, member of the Silesian Society of the Curious in Nature.*
>
> *The doctor describes the genera of crustacae, ending with an argument for the existence of underground rivers in which swim fossil (but not yet petrified) fishes, which, as some of the ancients found, were of unpleasant taste; occasionally even hurtful. There were even believed to be fishes living underground without water, and these notions of fossil life were applied to the study of petrifications. If other fishes, why not crabs?*
>
> *It has been taught that there was a great subterranean flood into which, under Mount Caucasus, subterranean rivers poured, and that through underground channels this flood sent water to the mountain-tops, whence it came forth in springs, and with the water some of its crabs. Thus all the crabs of the upper world were, some said, fresh water, until they became accustomed to the sea. But of this, says Dr. Sachs, every man is free to think as he pleases.*

A hundred and twenty-five years of biological assessment hasn't borne out the good doctor's evolutionary argument, but as the distinguished editor allows, "Every man is free to think as he pleases."

Fowl

The Zirknitzer See, a Bavarian lake described as early as 1688, is fed by a number of springs and drained by a number of sinks. Water entirely disappears from the Zirknitzer when the local water table falls below the lake floor. From Charles Kingsley's Madame How and Lady Why, or First Lessons in Earth Lore for Children (1873) comes a report of subterranean ducks.

> *You would not wonder, either, at the Czirknitz Lake, near the same place, which at certain times of the year vanishes suddenly through chasms under water, sucking the fish down with it; and after a certain time boils suddenly up again from the depths, bringing back with it the fish, who have been swimming comfortably all the time in a subterranean lake; and bringing back, too (and, extraordinary as this story is, there is good reason to believe it true), live wild ducks who went down small and unfledged, and come back full-grown and fat, with water-weeds and small fish in their stomachs, showing they have had plenty to feed on underground.*

E.A. Martel, a luminary of cave exploration whom we will meet in Chapter 49, Subterranean Watercraft, expressed his opinion regarding the Zirknitz in "British Caves and Speleology," The Geographical Journal 10, July 1897.

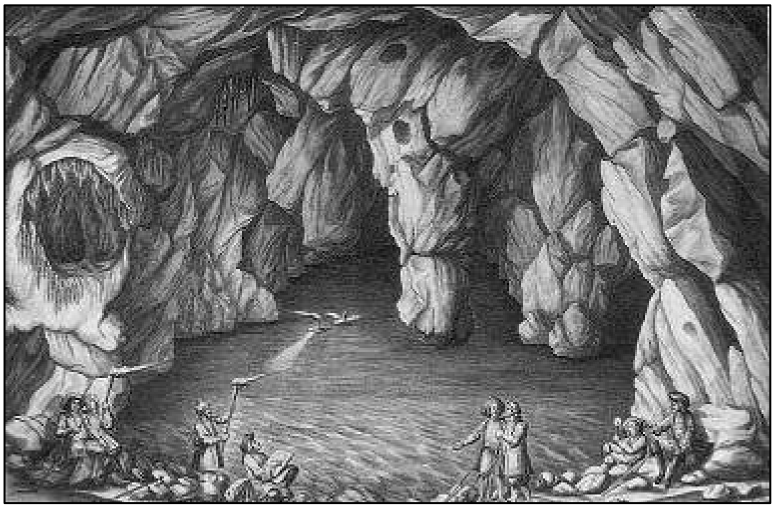
> *The turhughs, or lakes with changeable water-level, alternatively fill and empty themselves by the bottom, according to the oscillations of the swelling or the decrease of the waters; they are simply the overflowing of the subterranean channels which drain the calcareous ground through its fissures. They repeat here exactly what takes place in the famous lake of Zirknitz, in Carniole of which the irregular ebbing and flowing were so long unexplained.*

> *The chief causes of the multiplicity of these lakes, and the frequency of the phenomena in Ireland, are the slight altitude of the ground and the feeble slope of the subterranean waters which ensues.*

While slope is a factor, it's not the cause, but Martel's correct about the plumbing.

The 1748 illustration to the right shows geese -- non troglobitic, we must note -- released in a water filled Moravian cave. A board rigged with a torch was tied to each bird and when pelted with stones, the frantic birds towed the torches in all directions, illuminating the cave.

Having flashlights, we of today do not endorse such practice.



Glowworms

The ceiling of Waitomo Cave in New Zealand is covered with Arachnocampa luminosa glowworms. The worms -- actually larvae of a fungus gnat -- employ wispy adhesive-coated threads to snag mayflies attracted by light. The hungrier the larva, the brighter it glows.

WaNZ
$38.00

The cave entrance is a limestone funnel that narrows from a 7-meter diameter to a 1-meter maw. It is said that one can hear the roar of a rapids beyond, but outside of fiction, cave waters don't flow rapidly.

From "A Glowworm Cavern," Living Age, January 18, 1896,

> *These wonderful Tasmanian caves are similar to all caverns found in limestone formations, with the exception that their roofs and sides literally shine with the light emitted by the millions of glowworms which inhabit them.*

Salamanders

We'll deal with subterranean 12-centimeter salamanders in the chapter to follow.

The claim of a 30-centimeter subterranean salamander, however, rests in western Pennsylvania, according to "Subterranean Stream Running Beneath Allegheny," The Friend, A Religious and Literary Journal, October 5, 1895.

> *There is a subterranean river flowing beneath the city of Allegheny. It is only one hundred and twenty-six feet below the surface of the ground, but it is inhabited by eyeless fishes of a kind*

> *which appear to be wholly unknown in any stream open to the light. The unknown underground stream appears to be connected with some stream on the surface, as there are minnows in it, which must have been drawn down from that source.*
>
> *A six-inch well was sunk and was drilled to a depth of` one hundred and twenty-six feet. At that point the tools struck what appeared to be a pool of water. The tools were taken out, and a pump put in to test the well. It was not like the flowing artesian wells, as the water did not rise to any great height in the pipe.*
>
> *No particular attention was paid to the well until the owners were ready to start it last April. The workmen who went to overhaul the pumps I noticed a strange sound coming from the well. On placing the ear to the top of the well, they heard what they described as a rumbling and roaring, like a great stream of water rushing through a rocky cavern. The noise came from far down in the earth, and could only be heard when close to the well. When the pumps are in operation it is completely drowned out by the noise they make.*
>
> *The owners of` the well heard the workmen’s story, and began to take an interest in the matter. They were then informed by the man in charge of the pumps that strange-looking fishes and crawling things were pumped up from the well from time to time. They gave orders that the next fish which came up should he saved. They were soon rewarded by receiving a most peculiar monster. It is very similar in appearance to a hellbender or water-dog, a species of` salamander, which is found in the Allegheny River. But it is without eyes. There is just a noticeable mark in the head, where the eye should he. The fish, if it can be called by that name, is twelve inches long and about an inch and a half through. The monster has no scales on it, but is covered with a skin like that of a snake. When found it was covered with a slime, which made it as slippery as an eel. It was at once placed in alcohol, and can now he seen at the butcher-shop at Madison Avenue and Vista Street.*

The specimen is no longer on display and subsequent wells have failed to confirm the length, but we will pursue our study of blind salamanders in whatever form of alcohol they may be found.

Blind Salamander
Pale Ale

The Olm

The olm, a blind amphibian endemic to the subterranean waters of southern Europe, is occasionally called the "human fish" because of its color.

The olm's eyes are undeveloped, while its senses of smell and hearing are acute. In contrast to most amphibians, the olm eats, sleeps, and breeds underwater. It has 3 toes on its forelimbs, but 2 on its hind feet.

The olm swims by eel-like twisting of its body and feeds on small crabs, snails and occasional insects. Controlled experiments have shown that an olm can survive up to 10 years without food. Longevity is estimated at up to 58 years.

Charles Darwin used the olm to exemplify the reduction of structures through disuse in On the Origin of Species (1859).

> *Far from feeling surprise that some of the cave-animals should be very anomalous…as is the case with blind Proteus with reference to the reptiles of Europe, I am only surprised that more wrecks of ancient life have not been preserved, owing to the less severe competition to which the scanty inhabitants of these dark abodes will have been exposed.*

The olm is depicted on the Slovenian 10-tolar coin.

PROTEUS ANGUINUS
10
REPUBLIKA SLOVENIJA
DESET STOTINOV
10

The Cave Itself

From the Utica Herald, October 22, 1910

> *"A curious freak of nature that apparently never has broken into the guidebooks is the pride of a country neighborhood near Prescott, Ariz." remarked F.X. Dorgan of El Paso, Tex. at the Raleigh.*
>
> *"This is called a breathing cave. The cave is in the lava formation on a high tableland near Prescott. In a wall of this cave is a crevice which is probably three inches wide and several feet long. A visitor stands close to this crack. He feels a current of air rushing out of it. This is not so strange. But, if he waits long enough, he will notice that the direction of the current has changed, and the air is being drawn into the crevice.*
>
> *"The people of the neighborhood have many theories to account for the change in direction of the air current, but I do not believe than any of them would stand the test of a scientist's examination. A subterranean stream is given as the probably cause. Just how the flow of an underground river could cause the direction of the air current to be reversed, I cannot agree.*

> *However, the crevice is there and the phenomenon exists. I think that some of the people are just a bit superstitious on the subject of the 'breathing cave.'"*

Omitted from this chapter are speculations regarding the subterranean swimmers found in fiction, but we'll add one for the record.

In Richard Tooker's Inland Deep (1936), intrepid spelunkers discover a prehistoric world containing dinosaurs, cycad forests, the eponymous body of water, and a large population of amphibious humans, the "Frog-Men." Our heroes fortunately have sufficient ammunition and dynamite to wantonly slaughter most of what they encounter.

While we may vainly suppose that future geological and hydrological understandings won't substantially differ from what we believe today, we've no such complacency regarding the life sciences. The title of the article below is the story, though of course it's not just China.

> "Out of Sight Out of Mind: Current Knowledge of Chinese Cave Fishes," Journal of Fish Biology 79:6, December 2011, by Yahui Zhao, R.E. Gozlan and Chunguang Zhang

A few recent biological science publications with the word "New" in the title,

> "A New Cavefish Species, Sinocyclocheilus brevibarbatus, from Guangxi, China," Environmental Biology of Fishes 86:1, September 2009, by Yahui Zhao, Jiahu Lan and Chunguang Zhang
>
> "Baronniesia delioti gen., A New Subterranean Leptodirini from the French Pyrenees," Zootaxa, February 2, 2009, by Javier Fresneda, Charles Bourdeau and Arnaud Faille
>
> "Ituglanis mambai, A New Subterranean Catfish from a Karst area of Central Brazil, Rio Tocantins Basin," Neotropical Ichthyology 6:1, January 2008, by Maria Elina Bichuette and Eleonora Trajano
>
> "Sinocyclocheilus donglanensis, A New Cavefish from Guangxi, China," Ichthyological Research 53:2, May 2006, by Yahui Zhao; K. Watanabe and Chunguang Zhang
>
> "Pimelodella spelaea: A New Cave Catfish from Central Brazil," Copeia, May 5, 2004, by E. Trajano; R.E. Reis and M.E. Bichuette
>
> "Four New Species of Groundwater Crustaceans Endemic to the Iberian Peninsula," Journal of Natural History 37:24, December 20, 2003, by AI Camacho

When it comes to uncovering Darwin's wrecks of ancient life, it seems that we're just getting started.

CHAPTER 48

DIVERSITY IN DARKNESS, TEXAN ECOLOGY

In the chapter just completed, we covered literally a world's worth of biology. In the chapter now beginning, we'll narrow our focus and look at how the puzzle fits together.

Texans are known for tall tales, often involving cowboys. On one subject however, the state's claim is no exaggeration. Texas has the world's most ecologically-diverse underground river.

As to what makes it a river,

The State of Texas designated it such, a topic of Chapter 63, The Law of Subsurface Streams.

The formation contains subterranean passages of up to 3 meters in diameter.

The passages sport catfish.

As to why it's the most ecologically diverse, one need but enumerate the critters.

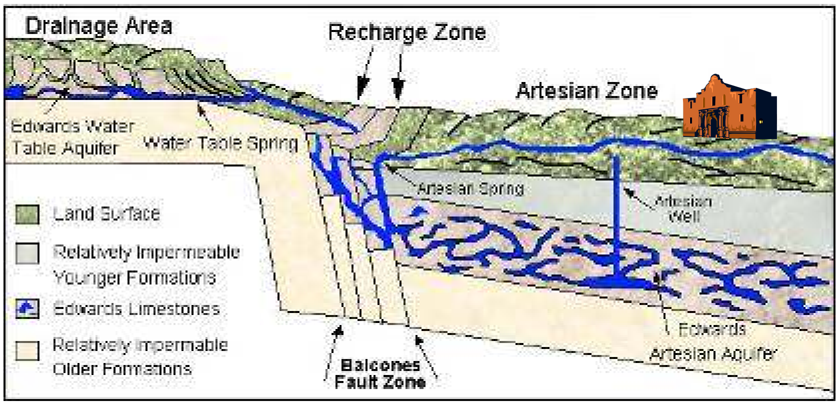
The Edwards Aquifer

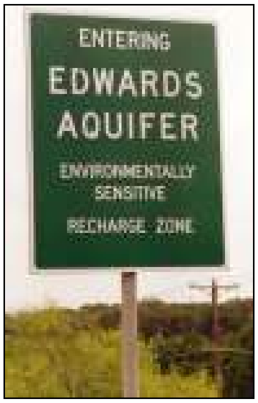
Over hundreds of millions of years, ancient seas flooded and receded, depositing limestone over what today is central Texas. About 17 million years ago, the Balcones fault lifted to form the Edwards Plateau to the north and west, while marine sediments buried the 130-meter karst layer on the south and east, together forming today's Edwards Aquifer, a water-rich stratum 280 kilometers long and from 8 to 64 kilometers wide, 600 meters beneath the surface in some places, honeycombed like Swiss cheese.

The Edwards Aquifer is not to be confused with much larger Ogallala Aquifer under the Texas panhandle, discussed in Chapter 38.

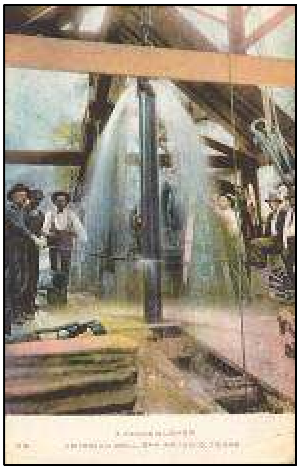
The aquifer serves as the primary source of water for approximately 1.7 million people, supplies agricultural irrigation and maintains the base flow of the Guadalupe River system.

As illustrated below, sinks, caves and porous terrain allow rainfall and surface runoff to recharge both the unconfined and confined zones. As the Alamo sits upon the aquifer, we've included it.


Drainage Area
Recharge Zone
Artesian Zone
Edwards Water Table Aquifer
Water Table Spring
Artesian Spring
Artesian Well
🟩 Land Surface
☐ Relatively Impermeable Younger Formations
Edwards Limestones
☐ Relatively Impermable Older Formations
Balcones Fault Zone
Edwards Artesian Aquifer


ENTERING
EDWARDS AQUIFER
ENVIRONMENTALLY SENSITIVE
RECHARGE ZONE

Dye tests have yielded fluid velocities as high as 2 meters/minute in the recharge zone. Groundwater in the artesian zone travels more slowly, perhaps a meter/day, but still rapid compared to flow in non-karst aquifers.



In 1895, the United States Fish Commission drilled a well in the Edwards and penetrated a 1.5-meter wide cavern at 59 meters. Up came not just artesian water, the photo to the right, but also a most unusual salamander and what seemed a menagerie of pale invertebrates. From the New York Times, April 26, 1896,

> *Queer Things from a Texas Well. The Unknown Creatures Said to Have Been Brought Up.*
>
> *Zoological experts at the Smithsonian Institution are busy studying and inventing names for the strange animals cast up by the wonderful artesian well at San Marcos, Texas. Some of them have been forwarded to Washington in bottles and jars, and much excitement has been occasioned among Government scientists. They declare that this is the most remarkable discovery of subterranean life ever made.*
>
> *The Government contemplates the establishment of a fish hatchery at San Marcos for the propagation of black bass, catfish and other pond fishes. Boring was begun for the purpose of obtaining water, which was struck in plenty at a depth of 188 feet. In fact, when that point was reached the drill suddenly dropped four feet, having: evidently reached a big cavity, and out poured a vigorous stream. The stream is still flowing at a steady rate of 1,100 gallons a minute and it bids fair to keep on indefinitely,*
>
> *The cavity struck by the drill was undoubtedly the tunnel of a subterranean river. That the water of this underground stream was full of life is satisfactorily proved by the great number of animals of various kinds which are thrown out at the surface through the artesian pipe. But it is not the quantity that excites astonishment nearly so much as their strange character. All of them appear to belong to species hitherto wholly unknown to science. There are shrimps of a queer kind, of which the well yields about half a pint a day on an average; sowbugs of a new genus, not related to any hitherto found in fresh water, and, most remarkable of all, salamanders six inches long with surprisingly developed legs.*
>
> *Where does the river come from? That seems to be the first question. It is a mystery up to date. In that region' the phenomenon of the "lost" river is frequent and familiar. Such a stream runs merrily for a distance and then sinks into the ground; perhaps it may reappear further on and disappear again. The supposition is that the subterranean river in question is a continuation of some river that has got itself lost far to the north. The geological strata in the neighborhood of San Marcos dip southward toward the Gulf of Mexico, and it is believed that there exists at a higher level a hidden cavern of considerable size, through which the stream runs. This undiscovered cavern, with no visible opening from above ground, furnishes the necessary supply of air to the creatures that live in the water that flows through the tunnel.'*
>
> *The scientists are waiting with interest for some fishes to come out of the wonderful well. They are sure to turn up sooner or later, it is believed, because they are not at all likely to he absent where there is so much food for them in the shape of shrimps, &c. Perhaps they also will prove to be of an entirely new species. It should be remembered that, the source of supply being inaccessible, the only animals thus far secured are those which have been brought to the surface of the ground by the merest chance. There would surely be good fishing in that subterranean river if one could get at with a hook and line.*

Shrimp, sowbugs and salamanders. We've no record of the hook-and-line suggestion, but fishing wouldn't have worked. Not for lack of fish, it turns out, but they dwell deeper than 60 meters.

Indeed, at the turn of the century, a strange fish, light pink in color, ruby lips and no eyes whatsoever, popped out of a 300-meter well near San Antonio, the first record of the toothless blindcat.

In 1905, an until-then unknown, tiny snail was noted in hatchery ponds, an immigrant from artesian pumping.

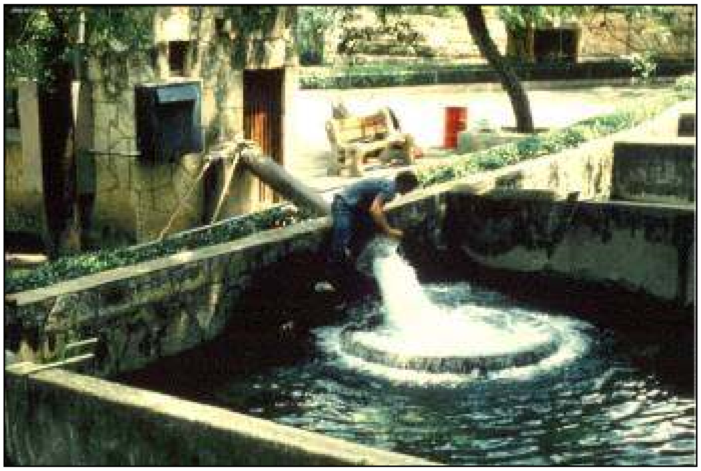
In 1920, another blind catfish appeared in a ditch beside a well a few kilometers from the Alamo. A third emerged from a deep well about 16 kilometers from San Antonio.

In 1940, four new types of crustaceans were noted at the hatchery.

Fifty blind catfish were discovered when a San Antonio food-processing plant drained its water tower in 1964, the structure storing water drawn from 430 meters.

In the mid-1970s, Southwest Texas State University at San Marcos began extensive biological studies of the hatchery well and by 1981, sampling by fine mesh nets placed over discharge pipes had expanded to 23 wells ranging in depth from 59 to 610 meters.

Two-day harvest at the old fish hatchery well



Placing a sampling net at the San Antonio Zoo well.

This sampling, along with springs and other wells, has produced evidence of a phreatic community -- one dwelling in or on subterranean water, as opposed to dry underground surfaces -- of 7 phyla, 15 orders, 22 families and 60 species, not counting protozoa and very small invertebrates not yet adequately documented, making the Edwards Aquifer ecologically more diverse than any other subterranean aquatic ecosystem in the world.

A taxonomic catalog is at the end of this chapter. For those of us not into Linnaean nomenclature, however, we'll be less exhaustive in the text, concentrating on fauna recognizable to the eye.

The U.S. Fish and Wildlife Service has designated seven species of the Edwards system, of which four are phreatic, to be endangered. The phreatic:

Texas blind calamander (Typhlomolge rathbuni)
Comal Springs riffle beetle (Heterelmis comalensis)
Comal Springs dryopid beetle (Stygoparnus comalensis)
Peck's Cave amphipod (Stygobromus pecki)

Although the non-phreatic species fall out of our underground-river focus, we'll add them for completeness.

Fountain darter (Etheostoma fonticola), a 2.5-centimeter surface-water fish
San Marcos gambusia (Gambusia georgei), a 4-centimeter surface-water fish not seen since 1982
Texas wild rice (Zizania texana), an aquatic grass, doubly outside our focus because it's flora

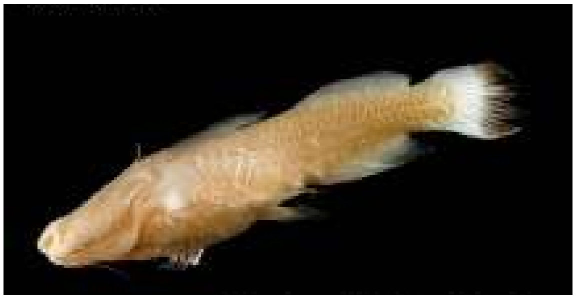
The U.S. Fish and Wildlife Service has also designated a threatened phreatic species:

San Marcos salamander (Eurycea nana)

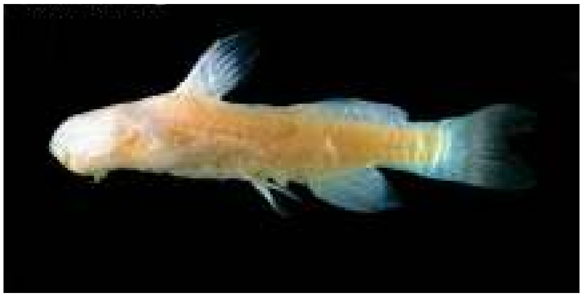
The fact that the Edwards is home to so many endangered species is largely why the ecology has been so heavily investigated. Below are a few members of the aquatic community.

Catfish

Two species of troglobitic catfish -- the widemouth blindcat and the toothless blindcat -- lacking external vestige of eyes and without pigment have been found in wells penetrating the Edwards between 400 and 600 meters. Instead of an air bladder -- an internal bubble that many fish use to stabilize themselves at particular water levels – both species possess a fatty blob that keeps them buoyant. Both species grow to approximately 14 centimeters.



Widemouth blindcat

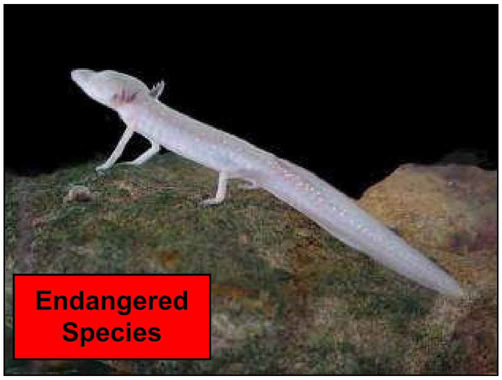


Toothless blindcat

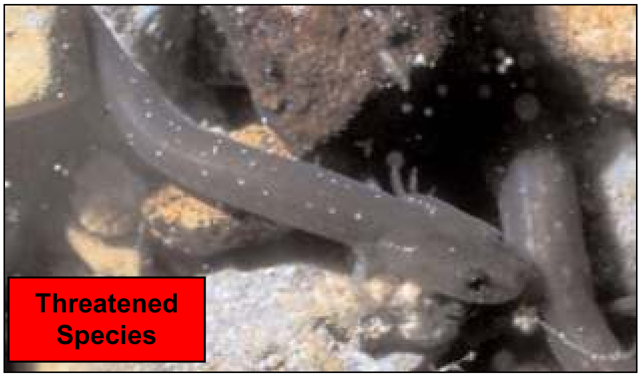
The evolutionary change suggests that these species found their way into the aquifer in pre-glacial times, perhaps to escape the colder temperatures on the surface.

Salamanders

Looking more like long-legged tadpoles with gills, more than a dozen species of blind salamanders inhabit the Edwards. Unlike the catfish, however, their habitat is in cave pools, not deep wells.



Texas blind salamander



San Marcos salamander

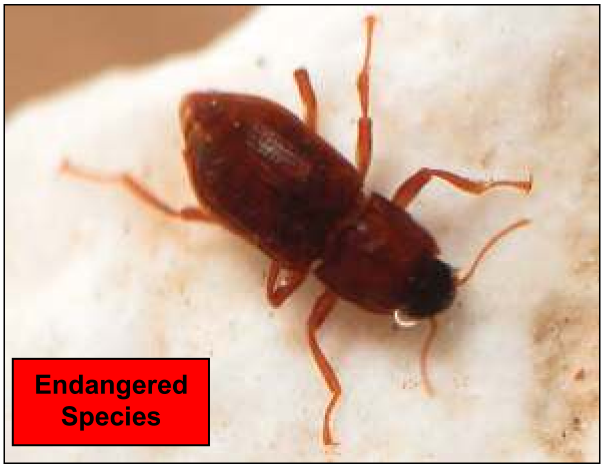
The Texas blind salamander, which grows to 12 centimeters, was the first species listed as endangered in the United States in 1967 and is considered by many to be the vertebrate most highly adapted to subterranean aquatic life. This slender amphibian has long legs that would not support it on land and is white or pinkish in color with a fringe of blood-red, external gills. Its head and snout are flattened and small black spots mark the location of vestigial eyes.

The San Marcos salamander is reddish-brown, 3 to 5 centimeters long. As its having a color should suggest, it's not exclusively subterranean. It lurks in the moss and algae of spring-fed upper waters.

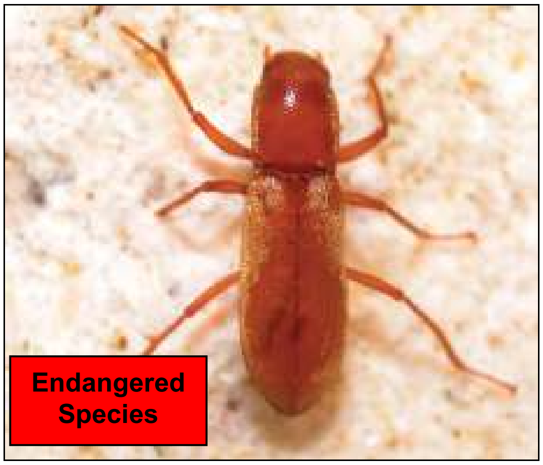
The catfish and salamanders are the only vertebrates inhabiting the Edwards, but there are many smaller invertebrates.

Beetles

Being just three species, aquatic beetles are but a small portion of the Edwards fauna, but as beetles are familiar to us, we'll mention them first.



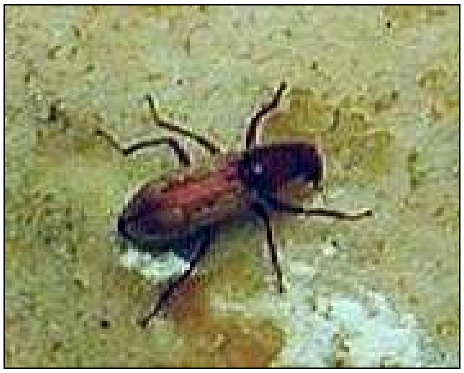
Comal Springs riffle beetle



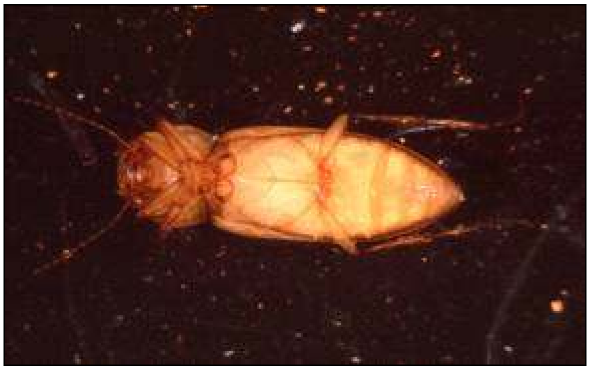
Comal Springs dryopid beetle

The adult Comal Springs riffle beetle has a narrow body about 2 millimeters long, and is reddish-brown in color. Unwettable hairs on its underside maintain an air film for respiration while submerged. As might be expected from its name, the Comal Springs riffle beetle is dependent on the habitat associated with Comal Springs.

The Comal Springs dryopid beetle, about 3 millimeters in length, is more subterranean in characteristics, having vestigial eyes and translucent, thin skin. Adults and larvae have been collected with drift nets placed over the spring sources.



Comal Springs diving beetle

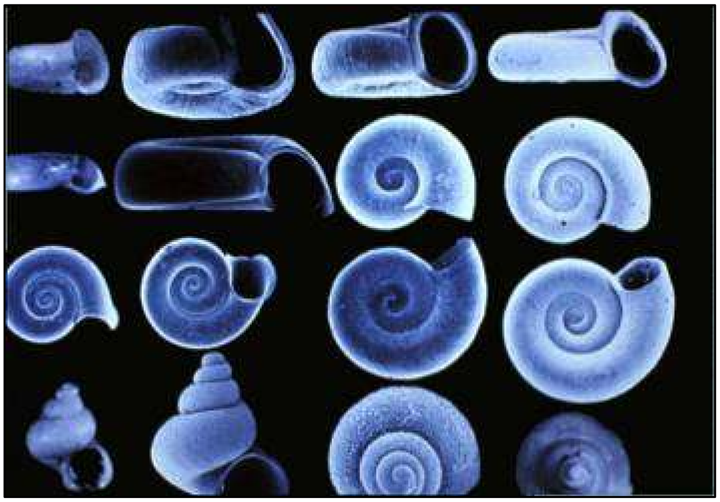


Edwards Aquifer diving beetle

The recently-discovered Edwards Aquifer diving beetle is another small, transparent, eyeless beetle that apparently spends its entire life cycle in the aquifer.

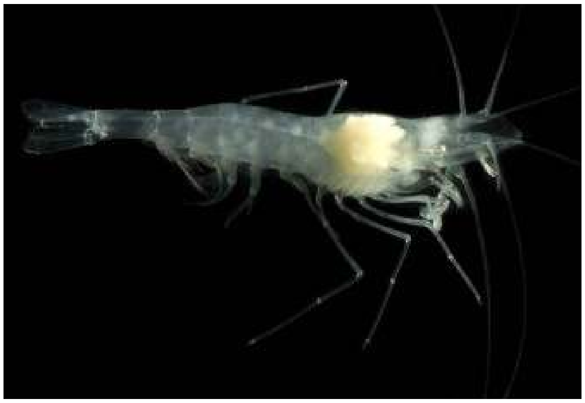
Snails

Snails are the most diverse invertebrate group in the aquifer, and represented by a dozen different species. Averaging 2 millimeters in size, the snails may be interstitial as well as phreatic.



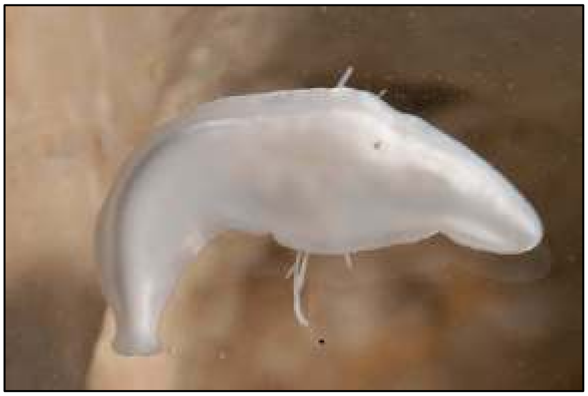
Shrimp

Shrimp are represented by two species, the Balcones cave shrimp, shown to the right, and the Texas cave shrimp.



Worms

This colorless, eyeless free-living flatworm Sphalloplana mohri exhibits polypharyngy, the condition of having multiple feeding tubes.



Amphipods

Amphipods are side-swimming crustaceans, too microscopic for most part to be known by common names. In the Edwards, Amphipods are represented by five families, making their order more diverse in this system than in any other surface or groundwater system, worldwide.

Four of the Edwards amphipod families seem to have saltwater origins, one coming from the Sea of Tethys which covered the Caribbean and Mediterranean before the continents shifted to their present positions. Another group's ancestors lived in deep waters, the closest extant relatives clustered in the Indo-West Pacific.

We'll note one particular species, Peck's Cave amphipod, because it's endangered. This aquatic crustacean, eyeless and unpigmented, is only found in the Edwards Aquifer. Little is known about its reproduction biology, life history or feeding habits.

Endangered Species

Who's for Dinner?

There are two major energy pathways at work in the Edwards Aquifer.

For organisms near the surface, the pathway is similar to that in caves around the world. Organic matter washed into the aquifer by rainfall and streambed infiltration serves as food for fungi and other decomposers. Protozoa and larger invertebrates such as the Sphalloplana mohri feed on these organisms and larger arthropods in turn feed upon them. Mysteries remain, however, as its unknown what the Comal Springs riffle beetle eats.

The San Marcos salamander feeds upon aquatic crustaceans, aquatic insects, and snails. The Texas blind salamander feeds on insects and small invertebrates nourished by bat droppings. If the Texas blind salamander becomes extinct, it's unfortunate for its parasites, the roundworm Rhabdochona longleyi, and the leech Mooreobdella microstoma.

The deep artesian section of the aquifer lacks such organic input. The infiltration zone nearest San Antonio, for instance, is nearly 30 kilometers distant. Rather, there is evidence of chemosynthesis, the energy source probably being fossil peat or petrocarbons. New wells sometimes produce an oily organic discharge with mats of colonial bacteria and fungal filaments. Could we peer into the limestone, we might see slime-lined walls with microbes devouring fossil material contained within the solidified sediment.

Unlike other catfish, the toothless blindcat has a sucker-like mouth on the underside of its head evolved to scarf the above microbes and fungi off ledges and cavern floors.

Water on the saline side of saline-freshwater interfaces is without oxygen and there the toothless blindcat is thought to prey upon a sulfur-bacteria-based food chain. Though unable to withstand the absence of dissolved oxygen for an extended period, the toothless blindcat may make short excursions into the anaerobic area to feed.

The widemouth blindcat appears to feed on any of the approximately 40 species of macroinvertebrates that share its artesian domain.

Not all snails are good citizens. Since the introduction of the giant ramshorn Snail, 4 centimeters in height and 5 centimeters in breadth, around 1983, riparian plants have been denuded of leaves or even grazed to the ground, degrading the habitat of the endangered fountain darter. As neither the rams horn snail nor fountain darter is subterranean, per se, we could ignore them, but as we are well aware, things subterranean and things superterranean tend to function in tandem, and ecology's no different.

Conservation and Recovery

In May 2008, the U.S. Fish and Wildlife Service released a Draft Recovery Plan to protect the endangered species. Preservation of the Peck's Cave amphipod, Comal Springs riffle beetle and Comal Springs dryopid beetle involve protection of springflows during droughts, as the effects of reduced flow include changes in chemical composition of the water, decrease in current velocity and corresponding increase in siltation, and an increase in temperature and temperature fluctuation. Stagnation of water may be a limiting condition for the Comal Springs dryopid beetle and Peck's Cave amphipod. Loss of photic zone of spring orifices may be limiting for the Comal Springs riffle beetle.

Common to all the species-specific conservation plans is a requirement to limit -- and perhaps curtail -- the extent of groundwater withdrawal. Discharges below 5.66 cubic meters/second at Comal Springs or 2.83 cubic meters/second at San Marcos Springs are tripwires for enforcement action. As Comal Springs typically declines below its critical level before San Marcos Springs does the same, the fountain darter at Comal Springs is typically the endangered species first at risk and 5.66 cubic meters/second at that location becomes the significant regulatory benchmark.

And as the state capital, Austin, sits upon the Edwards, the issue is politicized. From the San Marcos Record, May 30, 2007,

> *Piling a symbolic snub on top of a substantive one, Gov. Rick Perry this week refused to sign a resolution that would have designated the Texas Blind Salamander as the state's official amphibian.*
>
> *"The official designation of items and objects as much-loved objects of Texas should represent the entire state and not just one region or locality. This resolution designates an amphibian as the official State Amphibian of Texas that is found in only one Texas county. Such a small area does not adequately represent the State of Texas as a whole," Perry wrote.*

We're not fooled by the "represent the whole state" reason. Gov. Perry is a Republican and Friends-of the-Salamander are more likely Democrats.

The Ecology of Underground Rivers

Not only can a subterranean water body be diverse in biology, but the study of such an ecosystem can be diverse in scientific method.

On one hand, there are the pigmented, sighted creatures which spend at least part of their life cycle in day-lit springs and cave openings. Such biota can be observed, captured, measured and subjected to some degree of experiment. The ecological niche may be complex, but bit by bit, linkages can be discerned.

With the pressurized domain dwell the sightless and pale populations, biota adverse to the light of day. We can't inspect their abode without a drill bit. We can't observe interactions. We're unsure if we even know what's there. The only members of these populations we know are those accidently pumped to the surface, likely fatally stressed by the pressure drop. The challenge of understanding their natural lives would be akin to that of Martians who lack telescopes trying to understand the working of our Earth, based on snaring an occasional wayward spaceship.

Perhaps the best way to conclude our study of the Edwards Aquifer it to recognize that we've indeed come upon a complex world and to acknowledge that we've only hypotheses as to how it functions as a whole.

Edwards Aquifer Taxonomy

Phylum	Order	Family	Species
Chordata	Caudata	Spelerpinae	Eurycea chisholmensis, Salado salamander Eurycea latitans, Caverns salamander Eurycea naufragia Eurycea nana, San Marcos salamander Eurycea neotenes, Texas Salamander Eurycea pterophila Eurycea rathbuni, Texas blind salamander Eurycea robusta, Blanco blind salamander Eurycea sosorum, Barton Springs salamander Eurycea tonkawae, Jollyville salamander Eurycea tridentifera, Comal blind salamander Eurycea troglodytes, Valdina Farms salamander Eurycea sp., Comal Springs salamander
	Siluriformes	Ictaluridae	Satan eurystomus, widemouth blindcat Trogloglanis pattersoni, toothless blindcat
Annelida	Arhynchobdellida	Erpobdellidae	Mooreobdella microstoma
Arthropoda	Amphipoda	Hadziidae	Texiweckelia texensis Texiweckelia insolita Texiweckelia samacos Allotexiweckelia hirsuta
		Bogidiellidae	Parabogidiella americana
		Artesiidae	Artesia subterranea
		Sebidae	Seborgia relicta
		Crangonyctidae	Stygobromus balconis Stygobromus bifurcatus Stygobromus flagellatus Stygobromus russelli Stygobromus pecki
	Coleoptera	Dytiscidae	Hadeoporus texanus, Edwards Aquifer diving beetle Comaldessus stygius, Comal Springs diving beetle
		Dryopidae	Stygoparnus comalensis
	Cyclopoida	Cyclopidae	Cyclops cavernarum Cyclops learii Cyclops varicans rebellus
	Decapoda	Palaemonidae	Palaemonetes antrorum, Balcones cave shrimp Palaemonetes holthuisi, Texas cave shrimp
	Isopoda	Asellidae	Asellus smithii, Texas troglobitic water slater Asellus pilus Asellus redelli Caecidotea reddelli
		Cirolanidae	Cirolanides texensis
		Stenasellidae	Mexistenasellus sp.
	Ostracoda	Cypridae	Cypridopsis vidua obesa
	Podocopida	Entocytheridae	Sphaeromicola moria
	Thermosbaenacea	Monodellidae	Monodella texana

Phylum	Order	Family	Species
Foraminifera	Lagenida	Lagenidae	Robulus sp
Mollusca	Neotaenioglossa	Hydrobiidae	Phreatodrobia micra, flattened cavesnail Phreatodrobia nugax nugax, domed cavesnail Phreatodrobia nugax inclinata Phreatodrobia rotunda, beaked cavesnail Phreatodrobia conica Phreatodrobia plana, cavesnail Phreatodrobia imitata, mimic cavesnail Balconorbis uvaldensis, ghostsnail Phreatoceras taylori, nymph trumpet Hadocerus taylori Stygopyrgus bartonensis, cavesnail Texapyrgus longleyi, striated hydrobe
Nematoda	Spirurida	Thelaziidae	Rhabdochona longleyi
Platyhelminthes	Tricladida	Planariidae	Sphalloplana mohri

CHAPTER 49
SUBTERRANEAN WATERCRAFT

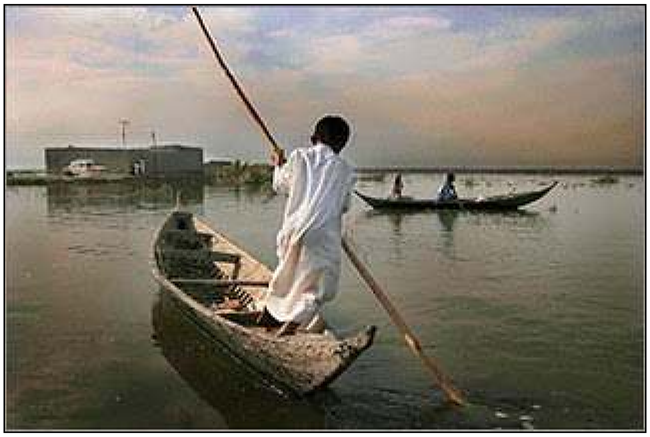
As to the design of Charon's craft, itself, we've no record. If we trust the artists of Chapter 33, Twenty-Five Centuries of Subterranean Portraits, it's most often a canoe, but artists will be artists.

We're not the first to wonder. Take, for example, "Charon's Boat," the obscure analysis by J.A. Richmond in the Classical Quarterly of November 1969,

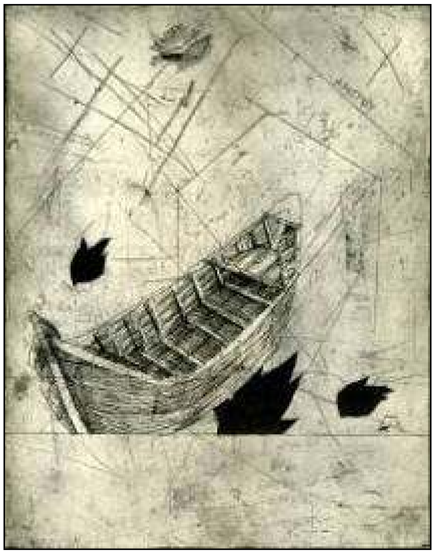
> *inreligata ratis, numquam defessa carina*
> *it redit in uastos semper onusta lacus;*
> *illa rapit iuuenes prima florente iuuenta,*
> *non oblita tamen tsedt repetitque senes.*
> *Eleg. in Maecen. 5-8*
>
> *Mr. E. Courtney adopts Ellis's defense of repetitque, argues convincingly as a consequence that sed must be replaced by a verb, and claims: "That verb can hardly have been any other than stat." He continues: "This will mean that Charon's boat, having ferried across the young, does not remain tied up at the quay forgetful of the old, but goes back for them." The difficulty of que in the sense of sed in the line as reconstituted is defended by a reference to Housman's note on Manilius, I.877. Still, the proposed line, non oblita tamen stat, repetitque senes, does not seem to be clear without a pause after stat, so that the reader will construe non with stat but not with repetit. This gives a very awkward rhythm indeed.*
>
> *There is, however, an alternative monosyllabic verb: nat. This will give the sense: "not forgetting, however, Charon's boat sails and returns for the old." The line then reads easily, as the rhythm is natural and indicates the sense. Furthermore the cause of the corruption becomes crystal-clear: nat lost its initial consonant after the final n of tamen; the scribe, noticing that the resultant at destroyed the meter, restored the meter, and left what seemed to be the sense unchanged by substituting the synonym sed.*

We're left unedified not only about the boat, but also where on the Styx it docks. Such is what earns university tenure.

We, on the other hand, need not mire in the Latin, but speculate that the bark of the early Charon may have been akin to the "mushhuf" of Iraq's modern Marsh Arabs.

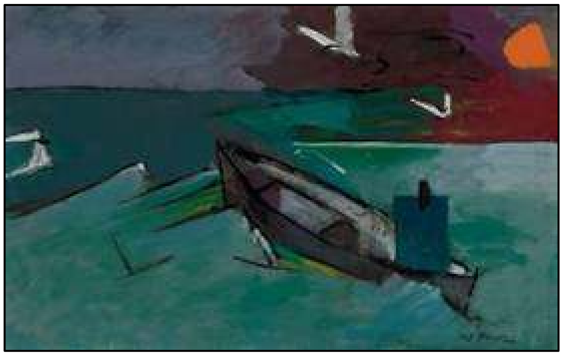


Modern Marsh Arab poling his mushhuf



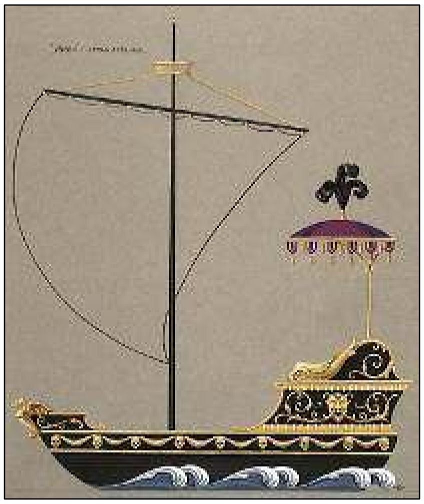
"Charon's Ferry," contemporary etching by Christian Harger.

Given the mushhuf's historic longevity, this reed craft may be a technology in near-perfect harmony with its environment. As the boat deteriorates, replace the sodden material with that newly-plucked. But as reeds don't flourish in the darkness, vessels of other make have borne those who've since explored the inky waters.



In his oil "Charon," Karl Knaths (1891-1971), depicts the craft as a conventional wooded rowboat, a design that wouldn't have been known to ancient Greeks. The boatman's away, but we're told his name.

As then or now, such boats aren't easily transported into the underground, however -- as we will come to see -- we'll not trust the post-facto artists.



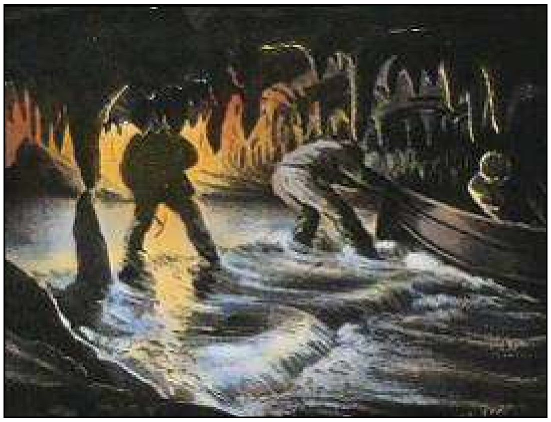
Gerard Gauci's "Charon’s Boat" 1989, a design for the Toronto Opera Atelier's production of Monteverdi's "Orfeo" could have been placed in Chapter 36, Underground Rivers in Sound and Song, but we'll dock it in this chapter for its nautical merit.

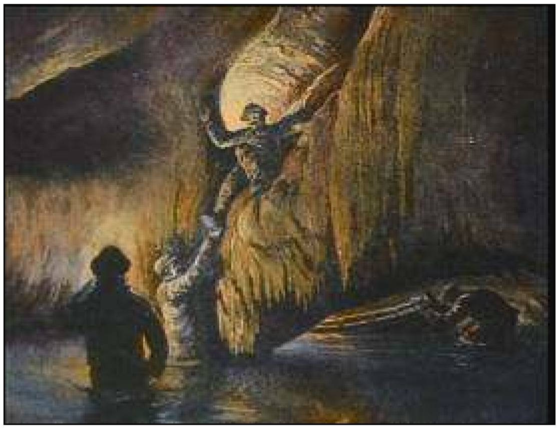
In chapters to follow dealing with tourism, we'll see fleet's worth of flat bottomed, weighty craft designed for stability. The second rule of the tourist trade -- the first being that of charging what the market will bear -- is to keep the clients happy. Chapter 65, Subterranean Shipwrecks, deals with failures to do so.

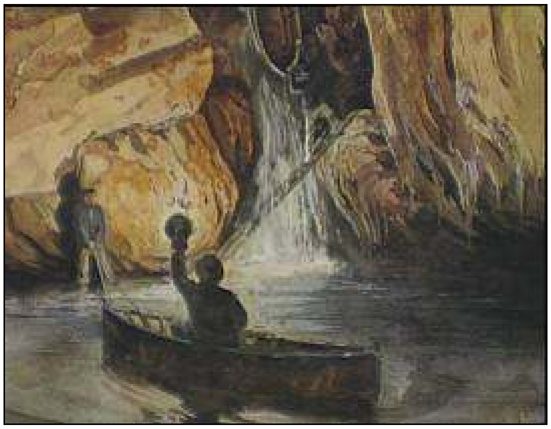
In this chapter we'll stay with subterranean explorers, the greatest of that fraternity being Edouard Alfred Martel (1859-1938), "Father of Modern Speleology."

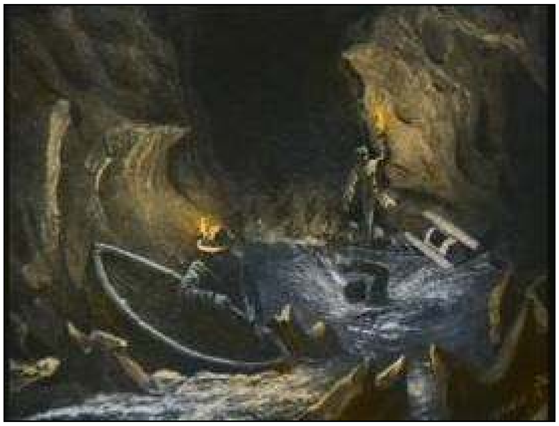
The "Father of" accolade, however, perhaps carries with it an unduly paternal tone. Martel was his era's equivalent of today's rock star, an explorer in the vein of Livingston, a venturer into one of the world's final frontiers.

Martel, an attorney by training, organized his cave descents in campaigns resembling Himalaya expeditions. Martel was frequently accompanied by artist Lucien Rudaux who sketched the events and blacksmith Louis Armand who was responsible for the equipment. Below are color reconstructions by Volker Zeller of Rudaux's illustrations.









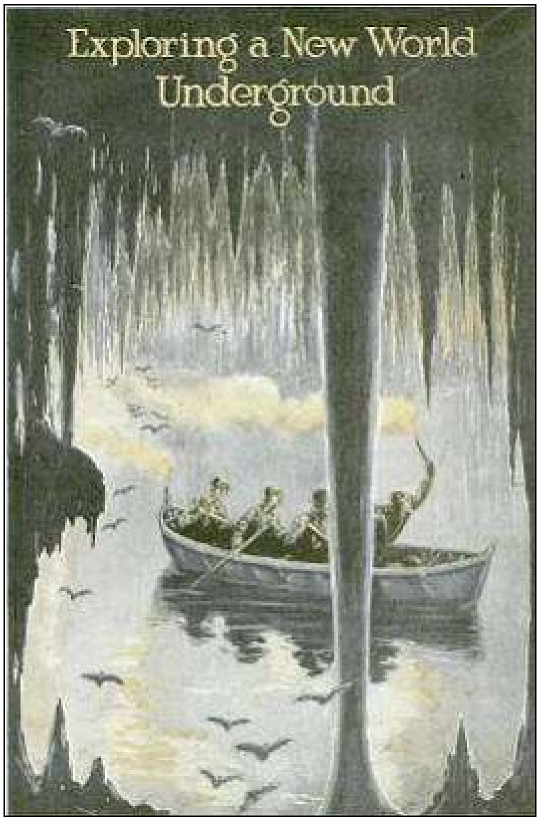
As one can see in the artwork, adventure was a selling point. Martel's reports became international bestsellers. An extract from his Les Cevennes (1888),

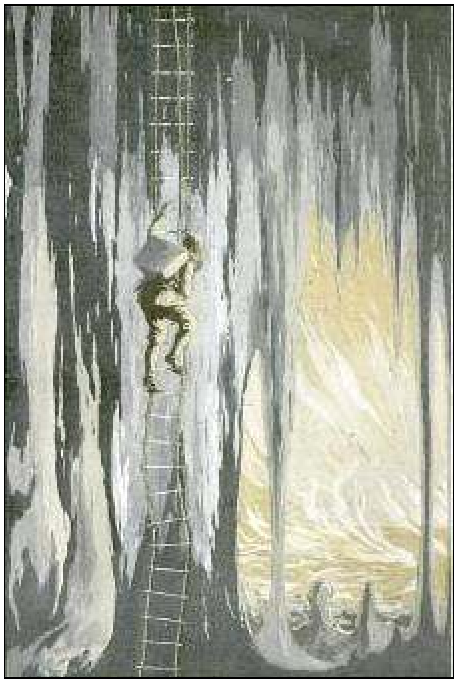
> *Here are natural wonders of inconceivable beauty: Kilometer-long caverns, full of huge stalactites and stalagmites. Subterranean rivers and lakes in a shimmering bed of crystal. A dark and mysterious realm, which, cast in the eerie glow of the magnesium lamp, is transfigured into a magical palace. A fantastic spectacle, just waiting to be discovered.*

Martel's use of boats constructed for cavern passage generated great interest. From "Martel and his Caves, Explorations Underground by a Frenchman," Boston Evening Transcript, October 3, 1896,

> *One might wonder what use the boats would be underground, but It should be remembered that in the part of France where much of his explorations have been conducted, there is little surface water, no rivulets, no brooks, no streams, only the great rivers. The rain sinks into the soil and through numerous crevices. It is conveyed to low beds which run through the caves and then out in "fountains" to the rivers. Most of the streams are subterranean, and for that reason, Martel has given much attention to boats and has chosen the portable boats of American makers. These are selected tor their strength and their lightness, for they are subjected to many odd experiences in navigating their strange waters, and the problem of getting them down to a river that lies six or seven hundred feet below the level of the country demands that there be little superfluous weight.*

"Exploring New Worlds Underground, Faces Death of Explore Wonders Beneath Surface of Earth," Popular Mechanics, September 1923, celebrated the French speleologist.


Exploring a New World Underground

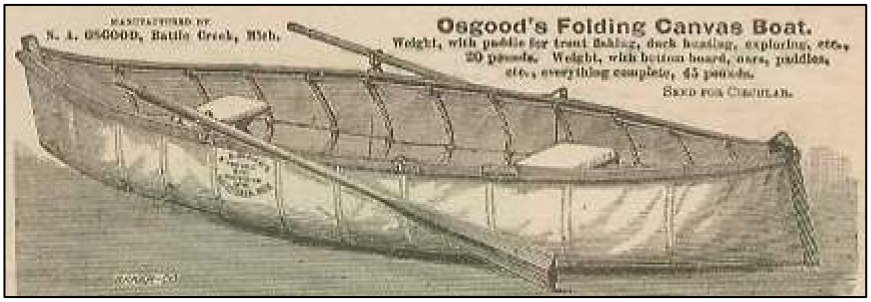


"Blazing Lake of Fire Found Far beneath Earth's Surface by Daring Explorer Who Risked His Life to Catch a Glimpse of Wonders Viewed by Human Eyes"

Martel employed the best available equipment for the crossing of underground rivers: a collapsible vessel covered by cotton fabric. From Martel's "Speleology," Report of the Sixth International Geographical Congress 6, 1895,

> *Of the outfits and appliances necessary for these descents, which lead from time to time to some mysterious marvel or valuable fact of scientific importance, I will here mention two only -- the portable canvas folding boats and the telephone. The boats come from Osgood and Co. (Battle Creek, Michigan), or from King (Kalamazoo, Michigan), or from Berthon (Paris). They weigh from 40 to 60 pounds, can be put together or taken apart in a few minutes, and may be packed either in a wooden box or in canvas bags. Wherever we find our passage underground barred by a pool or a stream, we have the boat lowered down, put it together, and paddle on into the dark unknown.*

The Osgood canoe folded concertina-like. The craft was said to be very stiff, light, strong, portable and of light draft. The 12-foot model, complete with fittings and receptacle, cost £9 10s.



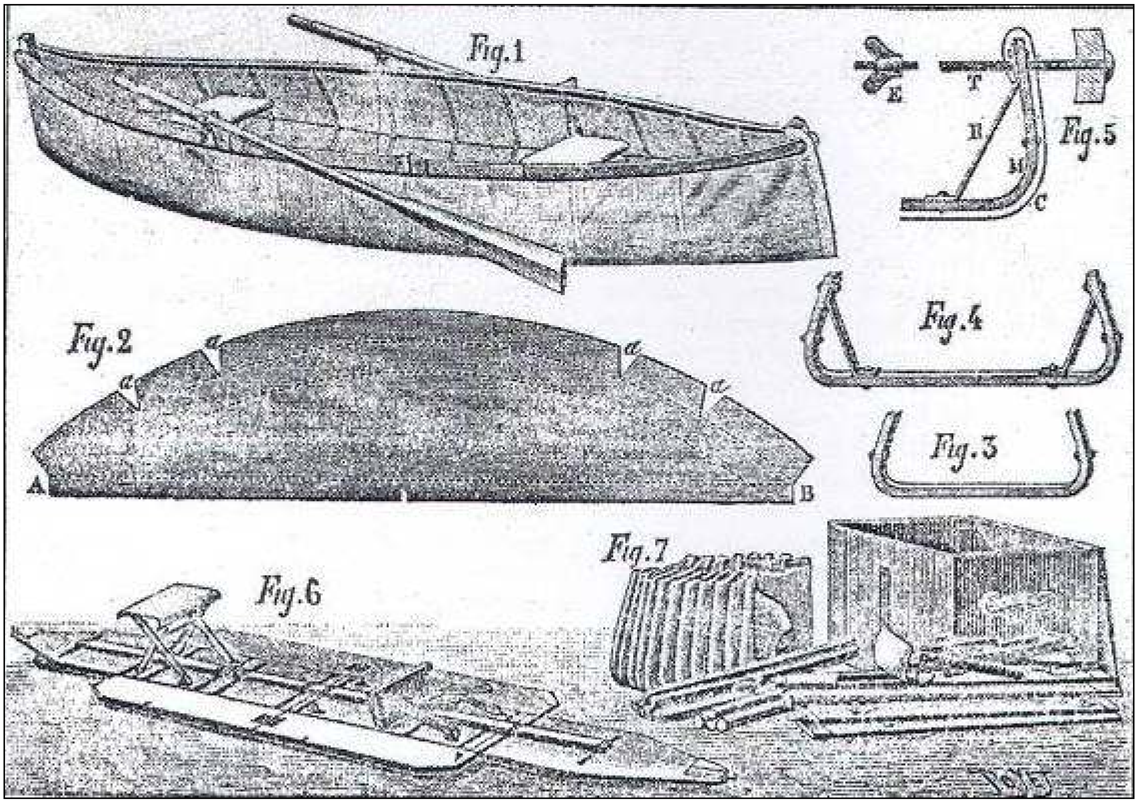
MANUFACTURED BY
S. A. OSGOOD, Battle Creek, Mich.

Osgood's Folding Canvas Boat.

Weight, with paddle for trout fishing, duck hunting, exploring, etc., 20 pounds. Weight, with bottom board, oars, paddles, etc., everything complete, 45 pounds.

SEND FOR CIRCULAR.

If one looks closely at the previous illustration from Popular Science, it's an Osgood. The drawings below illustrate the details.



KING FOLDING CANVAS BOAT COMPANY

Avbove, the King folding boat.

To the right, the collapsible Berthon boat came in lengths from 6 to 30 feet.

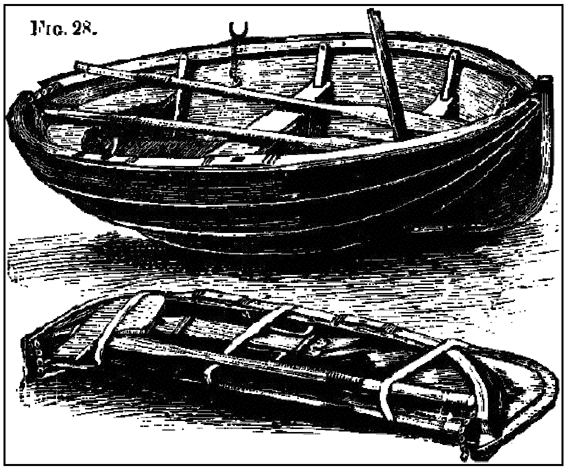
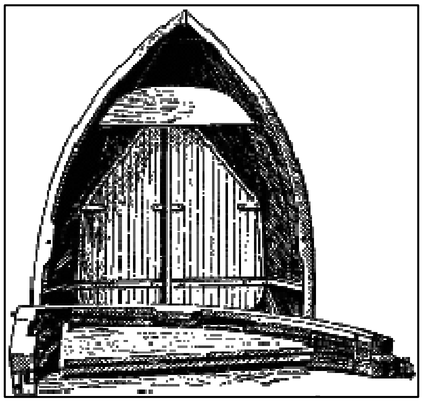


FIG. 28.

As described in the Manual of Yacht and Boat Sailing and Architecture (1913) by Dixon Kemp,

> *Berthon boats were made upon longitudinal frames of two skins of canvas. The keel, stem, stern post, gunwale, and longitudinal frames are of rock elm, and the keelson of pitch pine, the canvas skins being coated with a waterproof dressing. The thwarts are pine, supported by stanchions of American elm. When the boat is extended she is kept open by struts of American elm and iron, which work automatically. Those struts are stopped in iron sockets, whilst their heads are made to fit against the under side of the gunwale. The principal features of the construction of the Berthon type are the double skin of canvas and the longitudinal system of the framework. The manufacturers claim that whilst the longitudinal frames or webs, which are broad and flat, and jointed together at the tops of the stem and stern posts, enable the boat to be folded like the leaves of a book, they also give the craft great elasticity, so that they cannot be stove in in the act of lowering.*



One model of the Berthon boat was the Duplex, capable of division transversely into two equal parts, allowing a boat 12 feet long, 4 feet, 2 inches wide and 23 inches deep to be passed through a 13 by 6-inch hole.

If one inspects the earlier Rudaux's illustrations, they're most likely Berthons.

Edouard MARTEL
CRÉATEUR DE LA LUTTE CONTRE LA POLLUTION

So let us now visit some Martel's underground rivers in the order of his descents.

Bramabiau

The Bonheur River in south-central France flows on the surface for 6 kilometers until it reaches a karst area and vanishes into a cave, reappearing 700 meters downstream as the Bramabiau.

Above: Loss of Bonheur

Right: Resurgence of Bramabiau

Both caves were long-known, but the connecting passage had never been traversed.

Martel remarked on the passage in "Le Causse Noir et Montpellier-le-Vieux," Annuaire du Club Alpin Français (1884).

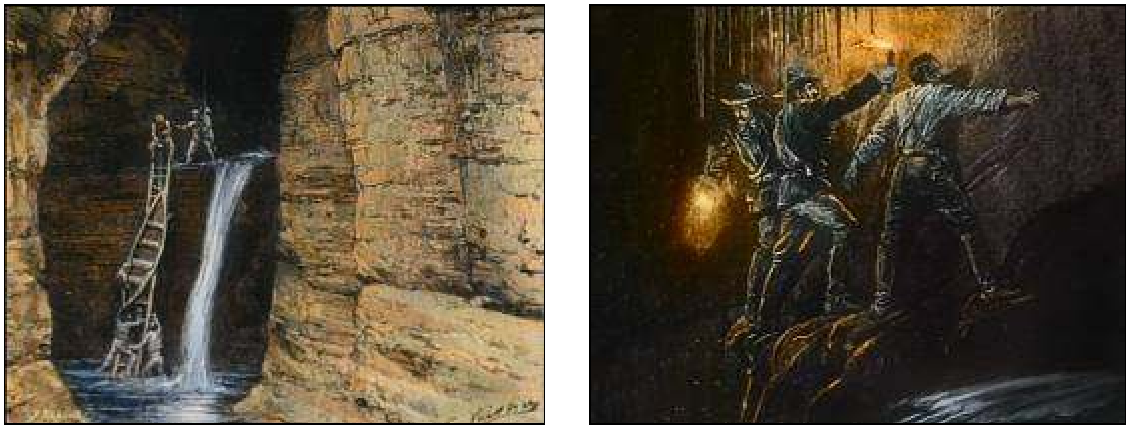
> *How many mine explosives should be used, how many dangers should be faced, in order to discover the capillaries and reservoirs of the Causses and solve the mystery of the communication between the swallow-holes and the valley caves? Who knows if some day, a brave explorer will extract from these limestone plateaux the secrets of their hydrography.*

Little did he know then that he himself would be that “brave explorer.” Fortunately for the gology, explosives were not required.

Four years later, on a holiday in the area, Martel persuaded a friend to explore this underground gorge with him. That date, June 27, 1888, is considered the birthday of modern speleology.

Martel first tried to follow the river uphill from the cave outlet until he reached the sixth waterfall where his equipment was insufficient. An attempt was made the following day from the other side, and the traverse completed.

Today the cave is equipped with a comfortable path. The tour does not cross the cave, however, as Martell did.



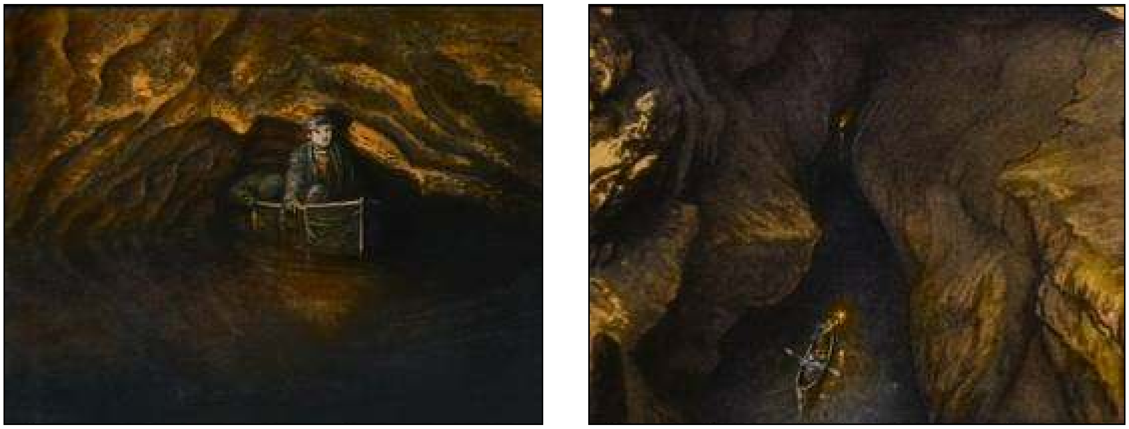
Martel/Bramabiau illustrations by Lucien Rudaux

Padirac

The Padirac, in the Causse de Gramat in France, was descended for the first time by Edouard Martel and crew in 1889. At a depth of 100 meters, they discovered an underground stream on which Martel and his cousin Gaupillat ventured in an Osgood for 2 kilometers with candles and magnesium strips as their only means of illumination. Excerpts from Les Abimes (1894),

> *We were both struck with an inexplicable feeling of fear. No human being before us had penetrated down to such depths. No one knows where we are going or what we will see. We are alone, two men in a boat -- cut off from the living world. Is this all a dream? We ask ourselves?*
>
> *Our progress is continually impeded by dripstones. Every time we encounter these barriers, we have to lift the boat out of the water and carry it to the next basin. Altogether during our expedition, we had to repeat this dangerous maneuver 34 times, clenching the candles between our teeth.*
>
> *Where will our journey end? Gradually we begin to feel uneasy. We are drenched. Our supply of candles is nearly exhausted. We have to turn back: We are overcome with fatigue and the obstacles facing us on our return journey are perhaps even more difficult to overcome.*
>
> *The exit of lac du Benitier is very narrow. Between two straight dripstone columns of 60 m height, the river disappears in the dark. Can we follow it?*

> *We know that our "Crocodile" is slightly flexible. With both hands we push our-selves along the walls. The boat's ribs are groaning, its fabric cover grinds roughly over the rocks, the boat is giving way! What if it breaks! The water is several meters deep! We're stuck, we can't move neither back nor forth! Another try -- we'll make it! And we did make it, through the Pas du Crocodile, a hole of perhaps 91 cm diameter. And our boat measures just 90 cm.*
>
> *Our progress is continually impeded by dripstones. Every time we encounter these barriers, we have to lift the boat out of the water and carry it to the next basin. Altogether during our expedition, we had to repeat this dangerous maneuver 34 times, clenching the candles between our teeth.*
>
> *Another lake, No. 7 in this expedition, opens before us beneath a dome, 20 m high and 20 m across. This is the end, it's closed all around. But no: In one corner there is a small tunnel, only 50 cm to 1 m high. From afar we can hear the music of drops falling into water. Will this magic world stretch on still farther?*
>
> *We have a quick discussion: Yesterday it has been raining, this morning it looked like thunderstorm coming up, and we have now been underground for seven hours. Perhaps it's raining again, perhaps the waters will rise! Shall we go back? Never mind! The unknown draws us on, irresistibly. Forward! Let's go on to new discoveries.*



Martel/Padirac illustrations by Lucien Rudaux

The popular press exalted the hero.

From "The Subterranean River Found in France," Brooklyn Daily Eagle, October 24, 1889,

> *The subterranean river recently discovered in the Miers district of the Department of Lot has now been traced a distance of seven miles to a point beyond which the three daring explorers, who undertook the task did not dare to venture, as the river there takes an abrupt plunge into the bowels of the earth to a depth impossible to fathom. It took three days and nights to accomplish this journey of seven miles and return, the greater portion being done in a folding boat made of sail cloth.*

From "A Subterranean River Journey in the Padirac," Frank Leslie's Popular Monthly, October 1891, by George C. Hurldut,

> *Returning the next day with he boat, the Crocodile, Mr. Martel and one companion embarked on the river, leaving the other two to wait for them in the gallery.*
>
> *For 1,300 feet the boat moved on the broad, deep stream in perfect silence. The passage was 20 feet wide between the high and smooth walls. The first obstacle was a stalagmite, over which it was necessary to lift the boat, which floated on successively through four oval expansions of the gallery, each a dazzling grotto filled with the most beautiful and fantastic forms of stalactites, fonts, bouquets of flowers, bass-reliefs, acanthus leaves, statuettes and brackets -- every imaginable decorative form, pure white and rose pink in the splendor of the*

> *magnesium light, reflected from the mirror-like surface of the water, and over one of the lakes a red and yellow stalactite 50 feet long and 12 feet in diameter at the roof, descended, gradually lessening to a point, to the water.*
>
> *"Here," says Mr. Martel, "even the water of the stream makes no noise. We hear the fall of drops from the vaulted roof on the river and on the stalagmites, with a silvery clear or duller sound, repeated and combined in the echoing space into a soft music, more harmonious and more penetrating than the sweetest earthly notes. No human being had preceded us in these secret depths; no one knows whither we are going, or what we see; we are isolated in our boat, far from contact with the life of the world. Never have we looked on any scene so strangely beautiful, and we turn to each other with the question, Is not all this a dream?"*

"Le Lac de la Pluie" by François Kollar, a Padirac photo.

As can be seen below, the Padirac of today is good bit more navigable, at least if we pay the price of admission. The boat trip is but 700 meters, half the length of Martel's, and in the Gouffre chasm on the limestone plateau.

Padirac
€9.20

Inlet

Outlet

Marble Arch

In 1895, Edouard Martel travelled the United Kingdom to explore Marble Arch Cave in Northern Ireland and Gaping Gill in Yorkshire.

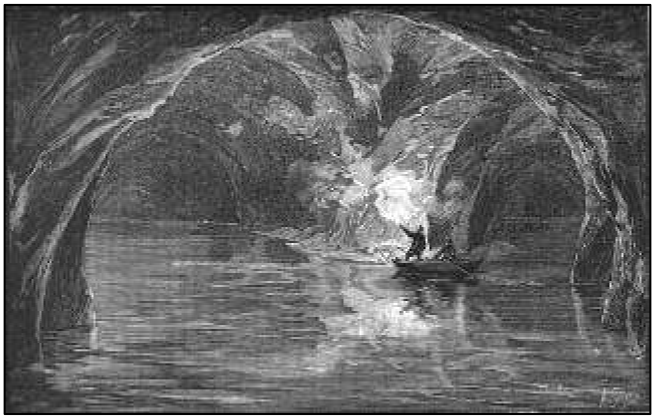
Marble Arch Cave is a 6.5-kilometer system formed by three rivers flowing off Cuilcagh Mountain, combining inside to form the Claddagh River which emerges at the 10-meter-high Marble Arch. The system was first surveyed by Martel in a folding boat.

From "British Caves and Speleology," The Geographical Journal, July 1897, by Martel,

> *But it is impossible to meet with a more striking example of the destructive powers of subterranean waters. Erosion, corrosion, and hydrostatic pressure have, by widening the*

> *natural fissures of the ground, formed a real sponge of stone, about 500 feet long by 200 feet wide. Under the continual action of the internal current, the rock has become, in some way, more and more carious, like a bad tooth. At the points the most attacked, the hollowing out has reached such a development that the overweighing mass fell in, thus producing the four funnels. In short, the formation by the falling in of ground, due to the sapping of a subterranean river, is nowhere, not even at St. Catzian-in-Wald, near Adelsberg* [modern Postojnska Cave, Chapter 72, Underground and Balkanized]*, more evident and more eloquent than here; and the partisans of the theory which attributes the origin of natural wells principally to this cause, will find at Marble Arch one of the best arguments in favor of their thesis.*

> *Behind the boulders, the subterranean stream occupies the entire section of a huge gallery. To the extent of 1000 feet we followed, in my folding boat, a great tunnel, previously unknown to man, elbowed in two places with sharp angles. The height and width of this tunnel vary from 25 to 45 feet; it is as imposing as the finest sections of the subterranean Piuka of Adelsberg.*



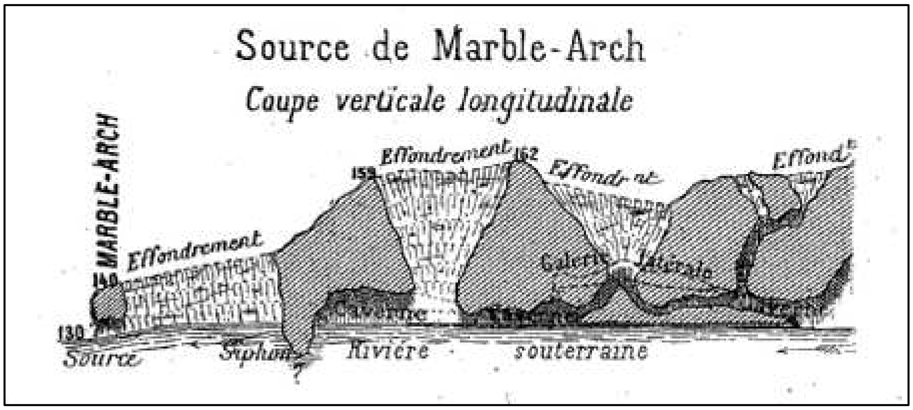
To the right: Martel/Marble Arch illustration by Lucien Rudaux

> *At the second elbow there is a cross-way, from whence a dry gallery is prolonged towards the north-east, the principal gallery coming from the south-west. At 650 feet from the cross-way we are stopped by the rocks approaching within 10 inches of the level of the water and not allowing our boat to pass.*

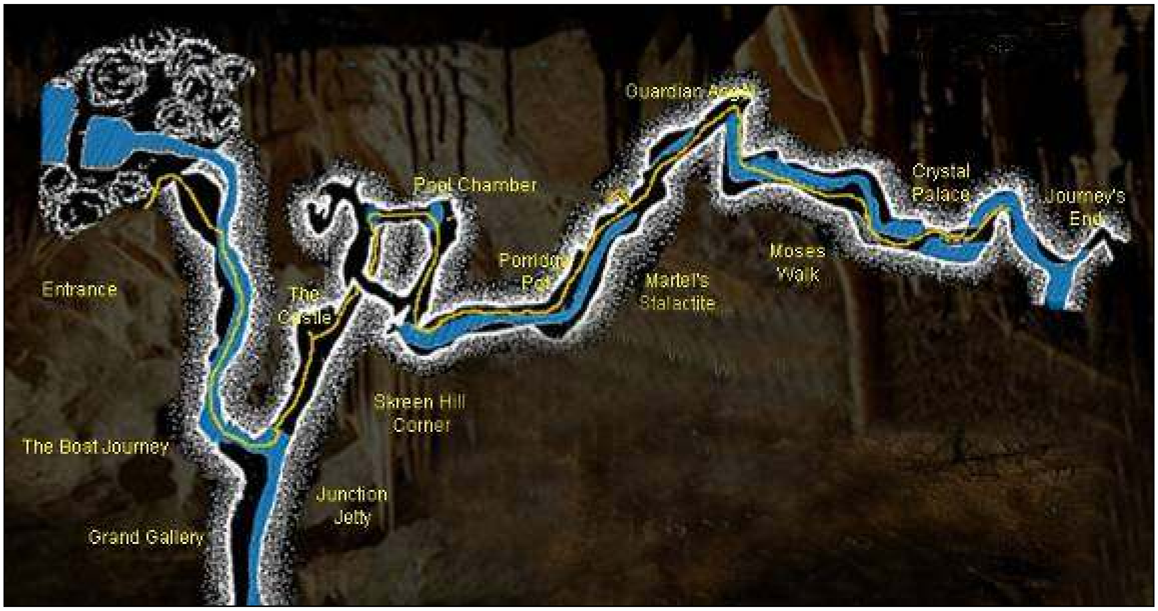
"Notes on Collecting Entomostraca, With a List of the Irish Species of Cladocera Known at Present," The Irish Naturalist V, 1896, by R.H. Creighton recounts the excursion.

> *On the 15th Mr. and Mrs. Martel and I drove to the Arch Spring, and Noon's Hole, bringing with us in a cart Mr. Mattel's copious equipment of cave-exploring apparatus. This consisted of a canvas boat, some hundreds of feet of rope ladders, a light portable folding wooden ladder, ropes, axes, compass, barometer, telephone, maps, &c.*
>
> *We first proceeded to Noon's Hole, which is a vertical shaft or swallow-hole down which a stream precipitates itself. Mr. Martel sounded the shaft with a lead-line and found the depth to be 150 feet. The rope ladders were then got ready and Mr. Martel began his descent; he could not, however, descend more than about 60 feet, as the falling water, which at the time was unusually high, broke over the ladder and rendered further progress impossible.*
>
> *On the 16th we visited the Marble Arch, bringing the same equipment. Here we were met by Mr. Bowles and his son, who accompanied us to the caves. Several streams, meeting underground, flow out at the source, under the "Marble Arch," a beautiful natural archway, cut off from the cave.*
>
> *The first cavern we explored we gained access to by means of an entrance at the bottom of a pit, formed evidently by the falling in of a part of the roof. After exploring several dry galleries and a vertical swallow-hole opening on the hill above us, we found on a lower level the river itself. Further progress was impossible without the boat, as a large and deep pool, an expansion of the underground stream, barred our way. The boat was brought into the cave, its constituent parts filling two large canvas bags, and was put together; by this means we were able to investigate this hitherto unexplored river. A detailed account of this voyage would occupy too much space, and no doubt it will in due time be fully described by Mr. Martel. The stream was "navigable" for about 300 yards.*

A detailed account was indeed in press. The cross-section is from Martel's "Sur les Siphons des Sources et des Rivières Souterraines," Comptes Rendus de l'Académie des Sciences 122, 1896.


Source de Marble-Arch
Coupe verticale longitudinale
MARBLE-ARCH
Effondrement
140
130
Source
Siphon
Caverne
Rivière
souterraine
159
Effondrement 162
Effondr nt
Galerie latérale
Effondt

A decade later, Irish naturalist Robert Praeger swam the passage with a candle in his hat. Today's Marble Arch has an alarm system and flood monitors in the passageways.


Guardian Angel
Pool Chamber
Crystal Palace
Journey's End
Porridge Pot
Moses Walk
Martel's Stalactite
Entrance
The Castle
Skreen Hill Corner
The Boat Journey
Junction Jetty
Grand Gallery

After 20 years of use and nearly a million passengers, Marble Arch's three 5-meter, 600-kilogram flat-bottomed tour boats were forced into retirement. The operation involved lowering the replacements down a 20-meter sinkhole, raising the water level at the cave entrance and using timber planks and a winch to see-saw the vessels over a weir. Regarding the retired vessels, one was removed intact, but the other two had to be cut in half.

Today's boats may be engaged at Jetty Junction.

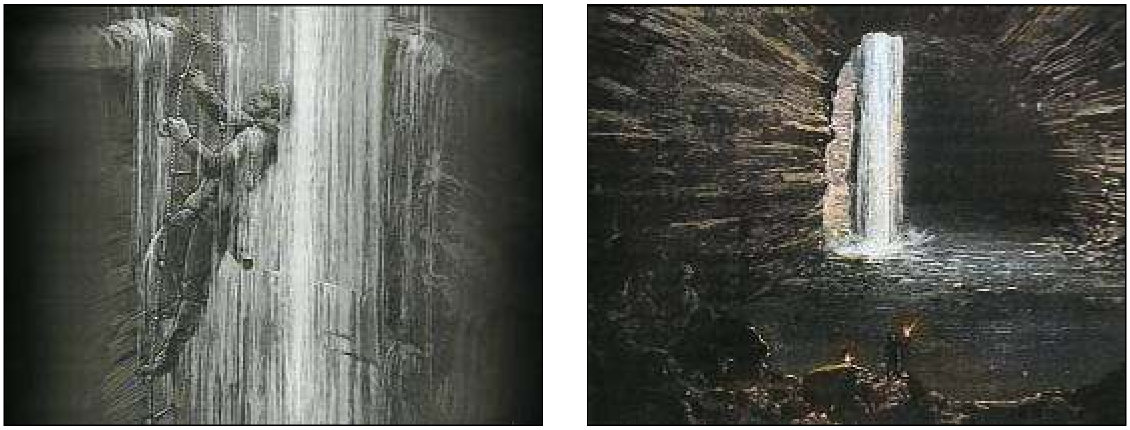
Marble Arch
€8.00

Gaping Gill

The photo to the right is of a hole in the North Yorkshire landscape. To Edouard Martel, any hole in the earth was a portal to discovery, and one this deep could not be ignored.

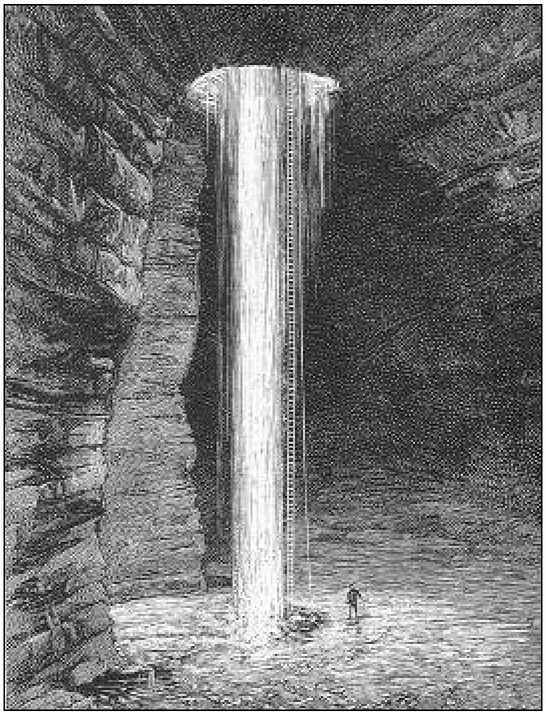
Martel's description of the Gaping Gill descent in Annuaire du Club Alpin (1895).

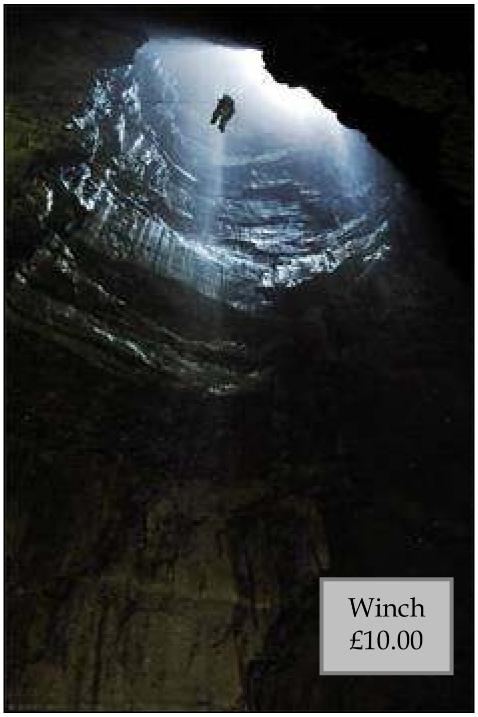
> *The first 20 meters go remarkably well. The rope is inclined gently towards the wall. I only have to let myself slide down. The waterfall is about 1 and a half meters to my left, drenching me with its spray. But the jet of water does not hinder my progress.*
>
> *Then I submerge into the waterfall: The water is cold and, despite my being well-buttoned up at the collar, runs down the back of my neck, sending shivers down my spine. I congratulate myself on having taken the precaution of wearing boots with holes, which allow the water to escape. Contrary to my fears, I am not benumbed by the shock of the cold water cascading onto my head.*
>
> *At a depth of 40 meters, my progress is suddenly halted*
>
> *"Hello! Hello! What's the matter?"*
>
> *The rope has become ensnared in a crevice; "We'll need 5 minutes to free it."*
>
> *"That's too long: I'm suspended in the middle of a waterfall and it's not exactly warm in here. Hurry up!"*
>
> *Despite my protests and lamentations, the minutes pass slowly as the torrent of water draws me in to the folds of a swirling mantle.*
>
> *Suddenly, at a depth of 70 meters, the shaft widens. The walls spread out abruptly at a perpendicular angle, and are transformed into a horizontal ceiling which vanishes into the pitch darkness. I am entering a huge cavern, stretching away into the blackness much further than the eye can see.*
>
> *At 1.45 p.m. I finally reach the floor of the shaft. The descent has taken 23 minutes.*



Martel/Gaping Gill illustrations by Lucien Rudaux

Today's tourist can be winched down the 110-meter main shaft -- twice the height of Niagara Falls -- in 60 seconds to the gallery 145 meters long and 35 meters high.





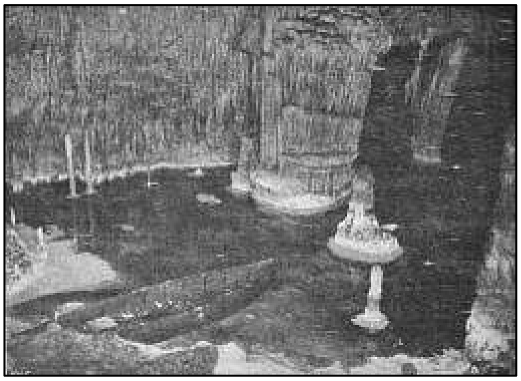
Cueva del Drach

The Cueva del Drach in Majorca merited inclusion in Chapter 36 by virtue of its music venue, but the cavern merits inclusion in this chapter as well by virtue of its tie to Edouard Martel. In exploring the cave in 1896, Martel and Louis Armand discovered the greatest underground lake known at that time, 115 meters in length and 30 meters in width.

From "British Caves and Speleology," The Geographical Journal 10, July 1897, by Martel,

> *The accompanying photographic illustration (taken with magnesium light in ten minutes) represents a corner of this lake, and shows better than any long description what a marvel is this mysterious and so long unknown.*

Note the canoe.



Martel's enthusiasm and astonishment is reflected in his report in Annuaire du Club Alpin (1896).

> *Thousands -- if not millions -- of tightly clustered stalactites hang down like long diamond tear-drops. Reaching down to almost touch the surface, they form perfect reflection on the water, creating the impression as if the boat were suspended between two pine forests.*
>
> *Some of the columns evoke images of subterranean Indian temples, full of elephant trunks and ears. Others resemble Egyptian capitals and pyramids of intricately entwined lotus leaves. Silently we navigate the boat between these islets and baldachins, careful to avoid breaking off one of these delicate needles with our paddle. So transfixed and captivated were we, that not*

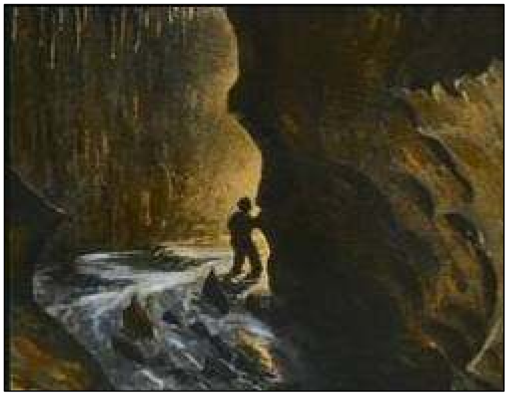
> *even the appearance of a water-nymph wearing a gown of foam could have surprised us any more.*

The modern eco-friendly visitor, however, should proceed with more caution than that of the discoverers, to wit,

> *This luxurious labyrinth abounds in all shapes and forms: Candles and rows of organ pipes, tapestries and banners, sea urchins and corals. To our chagrin, we have to destroy some of them in order to clear a path through.*

Labouiche

The Rivière Souterraine de Labouiche in the heart of Pyrenees was explored in 1912 by Martel. A Martel/Labouiche illustration by Lucien Rudaux is to the right.



Inflatables

The canvas canoe remained state of the art until in the 1920s when Robert De Joly introduced pneumatic boats. That technology been since refined, of course, but inflatables are yet the adventurers' choice.

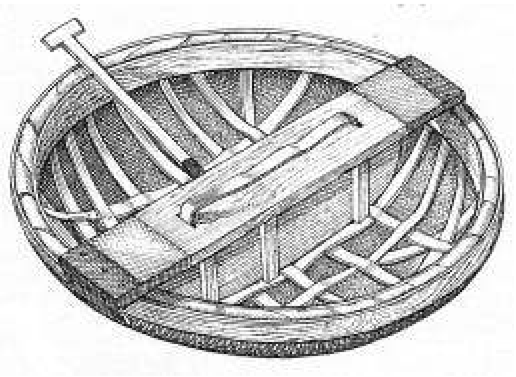
Norbert Casteret (right-most in the photo) describes the inflatable craft he used on the Labouiche in My Caves (1947).

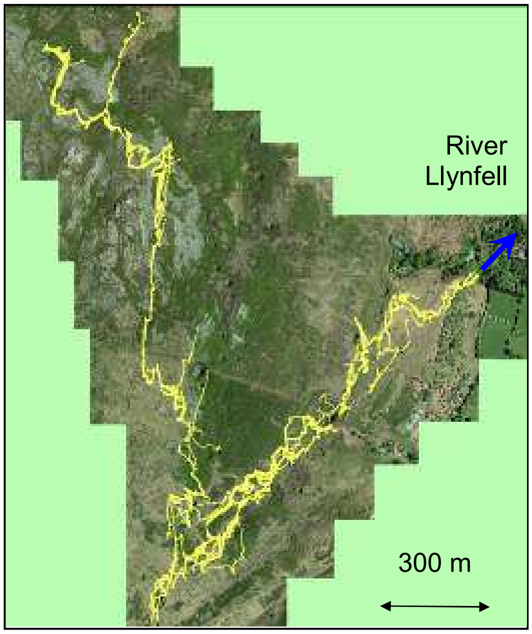
> *The bellows belong to the rubber boat and the bats or mud-shoes are the paddles for propelling my skiff over underground waters. The boat itself is .not here where light and heat might damage it, it hangs in the cellar, where the cool air and absence of light help to preserve it. It is four feet long by two feet broad when inflated. When deflated and rolled up it is not at all bulky and goes into a rucksack. The value of a boat like this, weighing only eleven pounds, is inestimable for getting about on water in caves, and nothing could take its place.*

Dan-yr-Ogof

The Welsh Dan-yr-Ogof cave complex is the head of the River Llynfell.

The locals who discovered the caves in 1912 used coracles, a traditional Welsh fishing craft, to cross the subterranean lakes.





Literature from the explorations in 1937 contains numerous references to the varieties of craft, a coracle, an inflatable rubber boat and a wood and canvas boat.

From the Yorkshire Ramblers Journal (1937) by E.E. Roberts,

> *A coracle had been bought and in it Mr. T. A. Morgan had voyaged 40 yds across the pool and 20 yds up a tunnel, landing near the foot of a waterfall. Pulling the coracle back with string, three others had followed, and after the leader had climbed the cataract and seen a watery tunnel beyond they had retreated.*

From the early history of Dan-yr-Ogof in the British Caver (1937) by Gerard Platten,

> *On Sept. 19th,* [1937] *fifteen cavers made a major attack and succeeded in passing the third lake, climbing a series of waterfalls, wading deep pools and, with a small boat which we carried with us, crossed the fourth lake reaching a remarkable series of dry, sandy, immense caverns, winding passages and everywhere brilliant with stalactite and stalagmite formations great and small.*

From "The 1937 Exploration of Dan-yr-Ogof," Journal of the BSA (1938) by Don Lumbard,

> *To those who are accustomed to the twists and turns of the flesh-removing Mendip caves, the prospect of exploring an extensive cave in Wales, where it is said that a carriage could be driven through the passages and where underground lakes had to be passed by using inflated rubber boats, was indeed inviting. There was also talk of a mighty whirlpool which made one imagine that an arm waving a sword might suddenly appear as if in challenge. However, even when the usual exaggeration of the enthusiastic caver was allowed for, the possibilities of an enjoyable trip were great. To our surprise the statements were substantially true, for Dan-yr-Ogof has now been explored for over a mile, there two lakes to be crossed by boats and a whirlpool is formed when the water is very low.*
>
> *We entered the cave at 8 am on the Sunday and leisurely went through the 1912 cave until we were all assembled on the strip of sand separating the 2nd and 3rd lakes, ready to begin the serious part of the exploration. Accordingly, two of us were dispatched in the canvas boat to see whether the journey up the falls could be accomplished, and report on the possibilities. A line was fixed to the boat and signals were agreed.*
>
> *In the distance we could hear the roar of water and as we paddled slowly on with our candles giving all too little light, the current became stronger until, when our sense of awe had reached its maximum, we saw the falls or rapids as they really are... We therefore moored the boat and negotiated the falls by climbing around the edge of the passage for a distance of about 20 ft until we came to a still pool which disappeared to the right. We clambered round the right hand side for a few yards but found that, if we were to continue, we should get fairly wet, which*

seemed unnecessary as there was a rubber boat with the main party. So back we went with the news that the falls could easily be passed but that the other boat would be needed.

From "Early Days in Dan yr Ogof" by Peter I.W. Harvey,

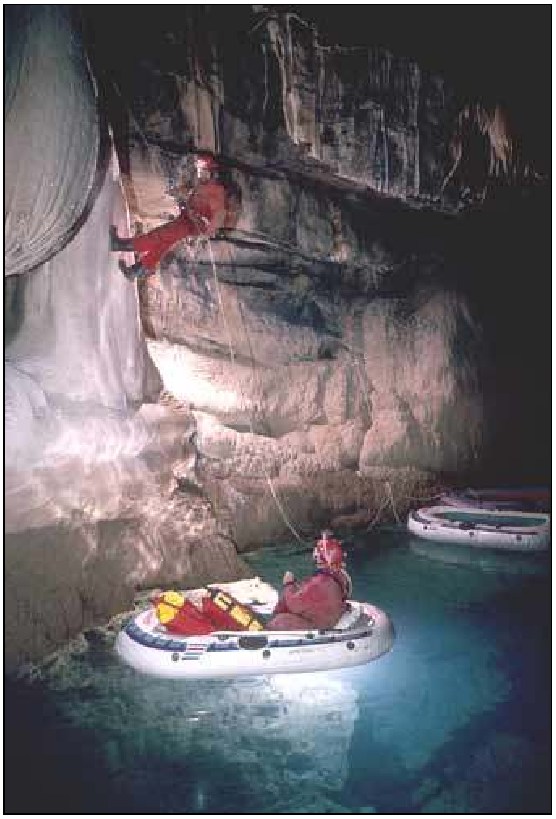
> *E.E. Roberts first entered the cave on the 23rd of May 1937 accompanied by Platten, Nelstrop and Gowing. They took with them a rubber boat, christened "Red Cymru"... They all used the boat to paddle round the lake and into the tunnel but did not make any attempt to approach the cascade.*

The Red Cymru

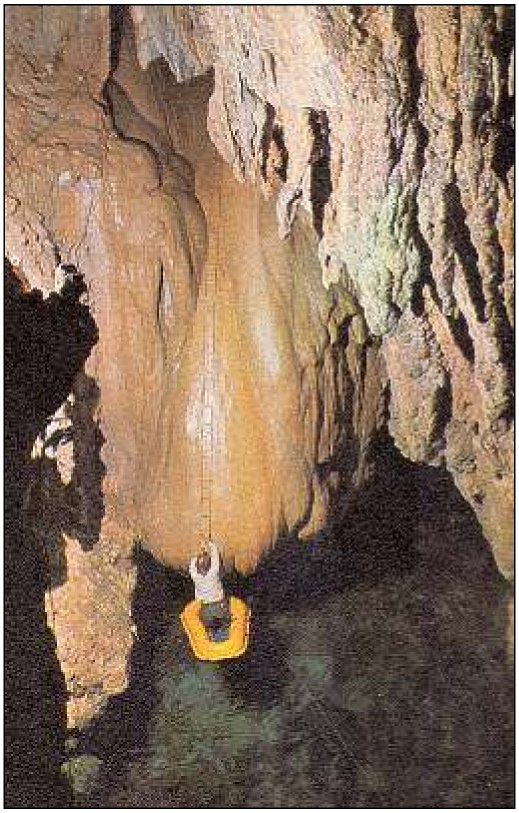
> *Later in the summer, T.A. Morgan, Ashford Price and Miss Coote crossed the Third Lake using a wood and canvas boat. They climbed the cascade and reached the lip of a fourth lake.*
>
> *At a rough guess the lake is about 15 yds across. On the left side, Bill Weaver fell out of the rubber boat into deep water while investigating water flowing into the lake.*
>
> *Attempting to cross the Third Lake in a coracle using a poor light must have been an awe-inspiring experience especially as the sound of the cataract round the corner could have been the river pouring down a hole in the floor ready to engulf both coracle and passenger.*

More-recent traversing the Dan-yr-Ogof's Green Canal by tube.

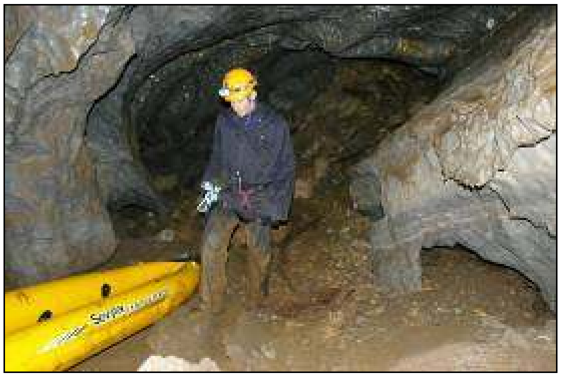
A few recent photos of inflatables used elsewhere.



Altinbesik Cave, Turkey

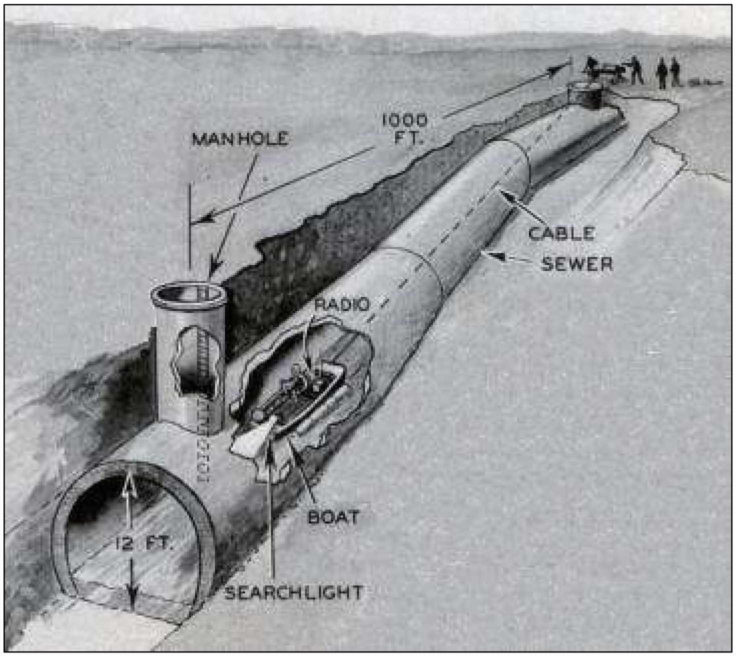


Gournier Cave, France



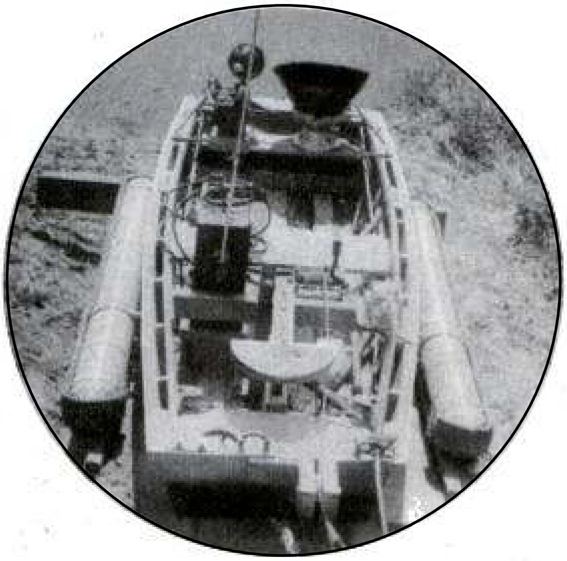
Devil's Bath, British Columbia

Not all underground rivers are natural, of course. As will be illustrated in Chapter 58, The Grand Tour, European Sewers of Distinction, sewers have -- or at least have had -- their own watercraft. In the chapter at hand, however, we'll note two non-tourist models.

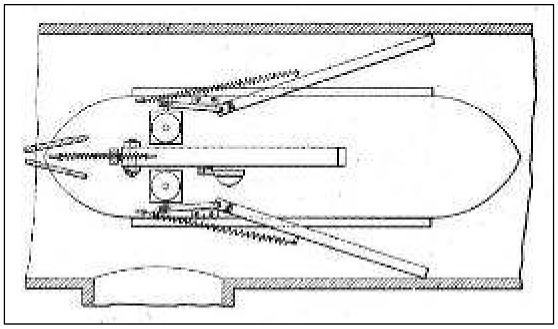


"Engineer Makes 6-Mile Sewer Voyage," Modern Mechanix, October 1936, features state-of-the-art technology.

> *A six-mile trip through deadly gases in the North Outfall sewer in Los Angeles, Calif., was made by Rufus Brown, assistant superintendent of sewers. The hazardous trip was made to determine the condition of the tunnel walls which had been exposed to the sewer's powerful erosive gases since 1922.*
>
> *A special unsinkable skiff that was propelled by the swift flow of the sewer stream was used. It carried special lights, a two-way radio, a camera and photoflood bulbs. Heavily insulated electric wiring was used to offset the possibility of a spark causing an explosion of the sewer gases.*
>
> *Brown wore a rubber suit fitted with an oxygen mask and a two-hour oxygen supply tank.*
>
> *The trip required 14 days as "hops" of only 1,000 feet were made so Brown could stop at manholes en route to report his findings to surface crews. The last mile was made in one trip due to difficult terrain. A calibrated cable running from the crew's station to the skiff enabled Brown to mark the location of wall faults.*



The skiff used, showing the two-way radio, the special; electric lamps and the calibrated cable.



A towed "Sewer Boat" per Patent 1,692,133, Nov. 20, 1928, this one unmanned and for a smaller pipe, rings a bell when passing a connecting pipe.

> *A Y connection being reached, the arm opposite the Y connection is swung back by the spring that is attached thereto causing its contact to complete the circuit and ring its particular bell.*
>
> *As the bells are of different sizes and tonal qualities it can be immediately determined from the sound which arm or arms have located outlets or it may indicate breaks in the pipe line. Two bells ringing indicate a Y connection or outlet; one bell ringing indicates a break.*

For non-explorers and non-sewermen -- that would be the most of us -- we've the the the tourism industry to transport us. We'll visit a number of attractions in the next three chapters and see what craft are for rent.

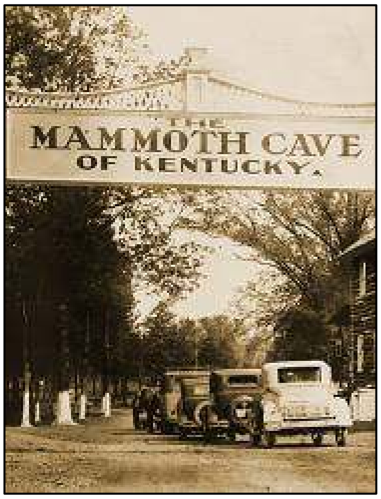
Mammoth Cave in Kentucky was also visited by Martel, but by tourist boat, the topic of the chapter to come..

CHAPTER 50

THEN, MADAM, YOU SHOULD GO AND SEE THE GREAT CAVE IN KENTUCKY

One need not visit Greece to boat the River Styx.

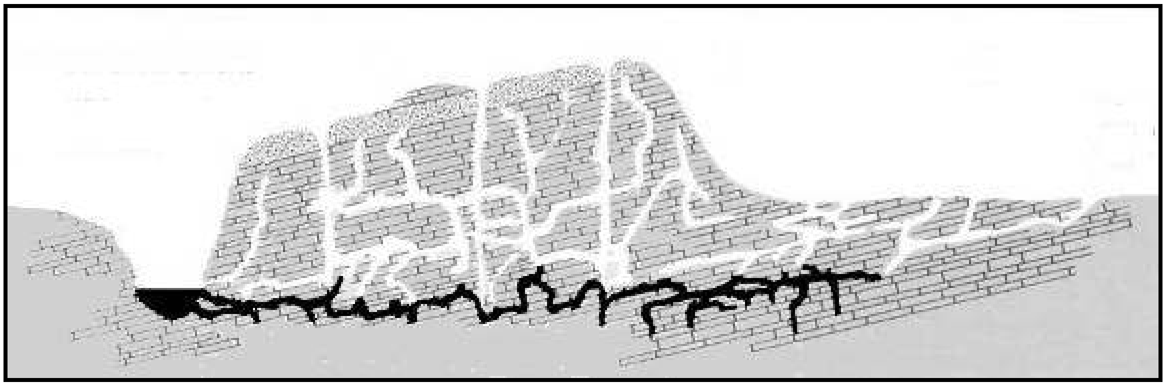
The world's longest explored cave system is Mammoth Cave, Kentucky, 590 combined kilometers in length. About 500,000 visitors/year visit Mammoth Cave National Park, the second-oldest tourist attraction in the United States. Park visitation generates some $60 million/year for the regional economy,



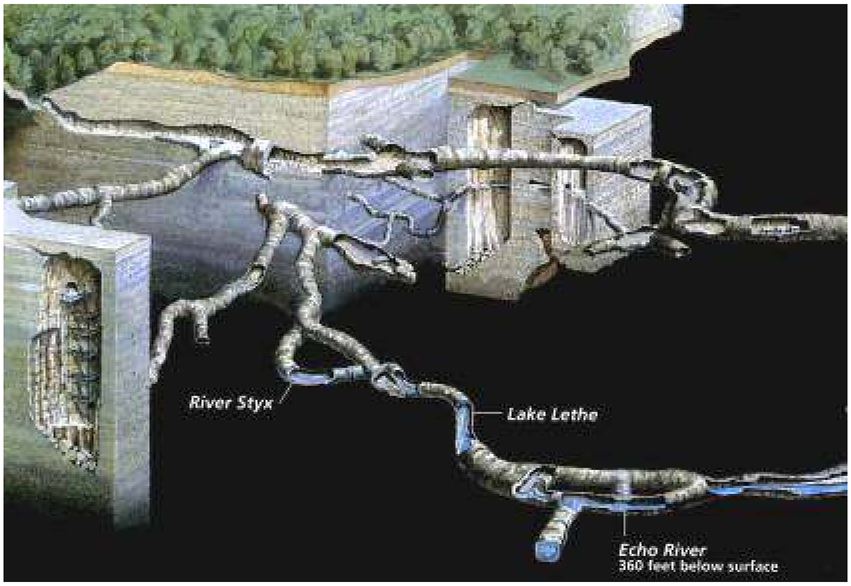
World Record

Longest Explored
Cave System
590 km

The figure below illustrates the cross-section of the Mammoth Plateau. Flow is to the Green River on the left.



Mammoth Cave features not only its own River Styx, but also Lake Lethe, Echo River (at only 2 kilometers in length, the system's longest river) and Lost River.



What's less than clear in the graphic is that, except in times of flooding, the subterranean waterbodies are not connected. "A Trip with Dr. Horace C. Hovey, the Great Cave Explorer -- The Marvels and Mysteries of Kentucky's Mammoth Cavern," Rochester Democrat and Chronicle, October 8, 1896, describes the rare case a continuous stream.

> *"Are the waters in the cave navigable to any extent?"*
>
> *"One who sees these subterranean streams at their lowest stage in the summer months and floats over them at leisure, awakening their wonderful echoes, has no idea of their tremendous volume and force during winter and spring. I have been in the cave when the Dead Sea, Lake Lethe, the River Styx, Echo River, and Roaring River were all combined into a mighty stream fully two miles long, as known, and how much further it flows into inaccessible channels, nobody knows.*

The subterranean River Styx is but 150 meters long, 2 to 4 meters wide and 10 to 12 meters deep, a tall rectangle, opposite in aspect to a typical surficial river cross-section.

Lake Lethe is approximately the same length and width as the Styx, and varies in depth from 1 to 12 meters. One's a called river and the other, a lake, in deference to classical allusion, not actual hydrology.

As for how these features came to be, Mammoth Cave provided scientists the opportunity for first-hand observation. Again we turn to Hovey.

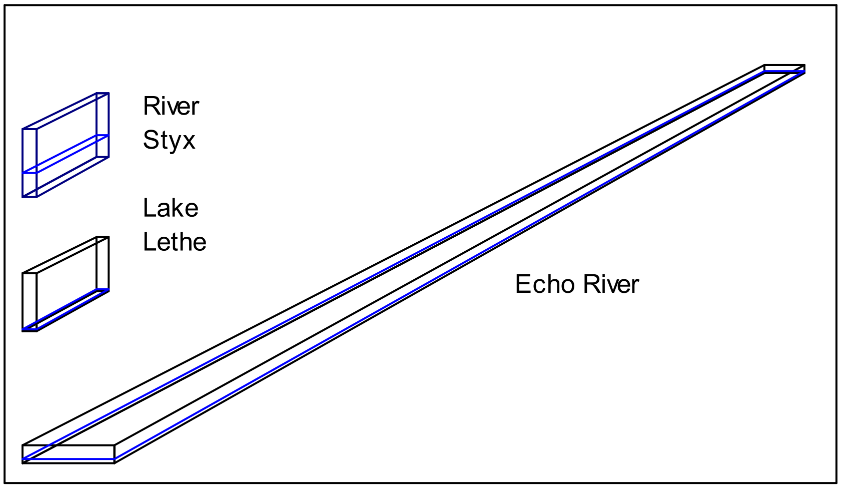
From "Mammoth Cave," Journal of the American Geographical Society of New York 28:3, 1896, provides us a snapshot of geological understanding at the turn of the century.

> *The pits and domes play an important part in forming the cave; and it has been considered by eminent authorities that they were made by the action of whirling water and pebbles from above downward. Mr. Hovey gave good evidence that they were caused by solution through the agency of acidulated water. The subterranean rivers, although easily navigable in summer, are combined in winter into a mighty rushing current, which is a powerful agent in hollowing out the long horizontal passage ways and undermining the arches, thus making the successive galleries for which the cave is noted. Mr. Hovey's conclusions are that none of the ordinary causes of cave-making, such as whirling water and pebbles, have had much to do with the making of Mammoth Cave; he believes that it has been made almost entirely by the chemical and mechanical action of water.*

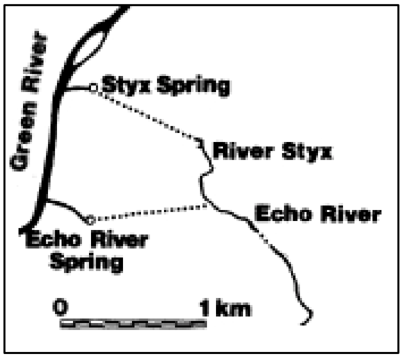
Note the "ordinary causes of cave-making, such as whirling water and pebbles." We now know that abrasion plays little role in cave making compared to that of dissolution, but Hovey' realization was mammoth -- small M, in this case -- in 1896.

Echo River is described in the July 1911 The Elevator, the literary magazine of Western Kentucky State Normal School, as "that lonely stream which so shunned man that it dug its bed far into the depths of the earth." At 2 kilometers in length, 65 meters wide at some points and 3 to 10 meters in depth, it's at least shaped like a proper river.

The perspective diagram provides a relative sense of the channels' shapes.



Prior to construction of Green River Lock and Dam Number Six in 1906, the Styx and the Echo fed different surface springs. The dam raised the level of both streams by 2 meters, mixing their flows, even during low flow conditions.



Divers have surveyed the 1,050-meter passage between the subterranean Echo River and its spring, submerged, and thus unseen, beneath a slough of the Green River. Tucked under a limestone bluff, on the other hand, River Styx Spring at least has the appearance of an emergence.

Echo River Spring
Mean discharge, 57 liters/second

River Styx Spring
Mean discharge, 3 liters/second

Although the resurges Styx is not 100 meters in length and of minimal -- often zero --discharge, we'll take a closer look at Charon's resurged stream in Chapter 55.

Boating the Waters

American 18th-century landscape tastes were heavily swayed by the Romantic Movement's veneration of transcendent nature. While America lacked the artful ruins that defined European tourism, the New World had scenery in abundance and Mammoth Cave became the American version of the Grand Tour, the circuit of significant sights that a person of culture should visit.

The earliest travelogue narratives took the form of letters published in newspapers, an example being the April 20, 1810, issue of Richmond Virginia's Enquirer. The author, who thought the reader "may perhaps not deem it uninteresting to have some information respecting the largest cave now known,'' described the cave as ‘‘one of the most sublimely beautiful and picturesque amphitheaters in the world." The formations were likened to "the different orders of Gothic architecture, columns, moldings and pilasters in embossed and stucco work." The place was essentially unknowable without the experience of being there, for "the most elaborate effort of the pencil would fail to do justice to the rich scenery and varied drapery with which the senses are delighted."

The narrative of discovery set a tone that was repeated and embellished in popular journals, women's magazines, and tracts throughout the 19th century. Mammoth Cave was touted in the likes of Scientific American, Vanity Fair, Appleton's Journal, Scribner's Monthly, Science, and The Century Magazine.

The following snippets from period publications are indeed somewhat repetitive, but we include the lot to illustrate the relentless journalistic enthusiasm regarding boating on the subterranean. We also cite in abundance because we enjoy the literary flourishes.

From a report read by Rev. R. Davidson before the Society of Adelphi of Transylvania University, January 16, 1840,

> *The river is a stream of water twenty feet wide and they said as many deep. It was discovered only about a year ago. Its current is very sluggish, as has been proved by launching a piece of wood bearing a lighted candle on its bosom.*

The discovery is credited to Stephen Bishop, a slave. Unusual for the era, Bishop was accorded full credit.

> *Accordingly, lifting the skiff over the rock, they launched it on the other side, and rowed, as they thought, for two miles. They beheld a great many new scenes and chambers never explored before.*

New scenes and cambers never explored! Not for long.

Rambles in the Mammoth Cave, During the Year 1844, by a Visitor (1845) by Alexander Clark Bullitt abounds in literary references.

> *Early the next morning, having made all the necessary preparations for the grand tour, which we were the more anxious to take from the glowing accounts of the party recently returned, we entered the cave immediately after an early breakfast, and proceeded rapidly on to River Hall. It was evident from the appearance of the flood here, that it had been recently overflown.*
>
> *Going on, and gradually ascending and keeping close to the right hand wall, you observe on your left a steep precipice, over which you can look down by the aid of blazing missiles, upon a broad black sheet of water, eighty feet below, called the Dead Sea. This is an awfully impressive place; the sights and sounds of which, do not easily pass from memory. He who has seen it, will have it vividly brought before him, by Alfieri's description of Filippo,*
>
>> *"Only a transient word or act gives us a short and dubious glimmer that reveals to us the abysses of his being -- dark, lurid and terrific, as the throat of the infernal pool."*

Bullitt's reference to Vittorio Alfieri's drama Filippo (1825) is audacious travelogue, but Mammoth Cave often engendered such prose.

> *Descending from the eminence, by a ladder of about twenty feet, we find ourselves among piles of gigantic rocks, and one of the most picturesque sights in the world, is to see a file of men and women passing along those wild and scraggy paths, moving slowly -- slowly, that their lamps may have time to illuminate their sky-like ceiling and gigantic walls -- disappearing behind high cliffs -- sinking into ravines -- their lights shining upwards through fissures in the rocks -- then suddenly emerging from some abrupt angle, standing in the bright gleam of their lamps, relieved by the towering black masses around them. He, who could paint the infinite variety of creation, can alone give an adequate idea of this marvelous region. As you pass along, you hear the roar of invisible waterfalls; and at the foot of the slope, the River Styx lies before you, deep and black, overarched with rock. The first glimpse of it brings to mind, the descent of Ulysses into hell,*
>
>> *"Where the dark rock o'erhangs the infernal lake,*
>> *And mingling streams eternal murmurs make."*
>
> *Across (or rather down) these unearthly waters, the guide can convey but four passengers at once.*

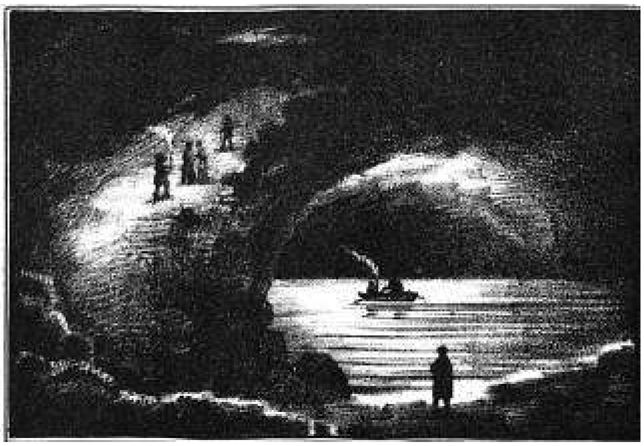
📋 Let's remember the River Styx ferry capacity -- four passengers in 1844. We will mark the subterranean fleet size with a clipboard symbol to track the growth.

> *The lamps are fastened to the prow; the images of which are reflected in the dismal pool. If you are impatient of delay, or eager for new adventures, you can leave your companions lingering about the shore, and cross the Styx by a dangerous bridge of precipices overhead. In order to do this, you must ascend a steep cliff, and enter a cave above, 300 yards long, from an egress of which, you find yourself on the bank of the river, eighty feet above its surface, commanding a view of those in the boat, and those waiting on the shore. Seen from this height, the lamps in the canoe glare like fiery eye-balls; and the passengers, sitting there so hushed and motionless, look like shadows. The scene is so strangely funereal and spectral, that it seems as if the Greeks must have witnessed it, before they imagined Charon conveying ghosts to the dim regions of Pluto. Your companions thus seen, do indeed --*

> *"Skim along the dusky glades,*
> *Thin airy souls, and visionary*
> *shades."*

The quote's from Alexander Pope's "Odyssey," an epic poem with which Bullitt presumes his reader to be familiar. But we mustn't dally.

> *If you turn your eyes from the canoe to the parties of men and women whom you left waiting on the shore, you will see them by the gleam of their lamps, scattered in picturesque groups, looming out in bold relief from the dense darkness around them.*



> *Having passed the Styx, (much the smallest of the rivers,) you walk over a pile of large rocks, and are on the banks of Lethe; and looking back, you will see a line of men and women descending the high hill from the cave, which runs over the River Styx. Here are two boats, and the parties, which have come by the two routes, down the Styx or over it, uniting, descend the Lethe about a quarter of a mile, the ceiling for the entire distance being very high -- certainly not less than fifty feet. On landing, you enter a level and lofty hall, called the Great Walk, which stretches to the banks of the Echo, a distance of three or four hundred yards.*
>
> *At the point of embarkation, the arch is very low, not more than three feet, in an ordinary stage of water, being left for a boat to pass through. Passengers, of course, are obliged to double up, and lie upon each others shoulders, in a most uncomfortable way, but their suffering is of short duration; in two boat lengths, they emerge to where the vault of the cave is lofty and wide. The boat in which we embarked was sufficiently large to carry twelve persons, and our voyage down the river was one of deep, indeed of most intense interest.*

A twelve-passenger vessel on the Echo, 1844.

> *The novelty, the grandeur, the magnificence of every thing around elicited unbounded admiration and wonder. All sense of danger, (had any been experienced before,) was lost in the solemn, quiet sublimity of the scene.*
>
> *The Echo is three quarters of a mile long. A rise of the water of merely a few feet connects the three rivers. After long and heavy rains, these rivers sometimes rise to a perpendicular height of more than fifty feet; and then they, as well as the cataracts, exhibit a most terrific appearance. The low arch at the entrance of the Echo can not be passed when there is a rise of water of even two feet. Once or twice parties have been caught on the further side by a sudden rise, and for a time their alarm was great, not knowing that there was an upper cave through which they could pass.*
>
> *The rivers of Mammoth Cave were never crossed till 1840. Great efforts have been made to discover whence they come and whither they go, yet they still remain as much a mystery as ever -- without beginning or end; like eternity.*

Such a line -- "whence they come and whither they go."

From Rambles in the Mammoth Cave, During the Year 1844, by a Visitor (1845) by Alexander Clark Bullitt,

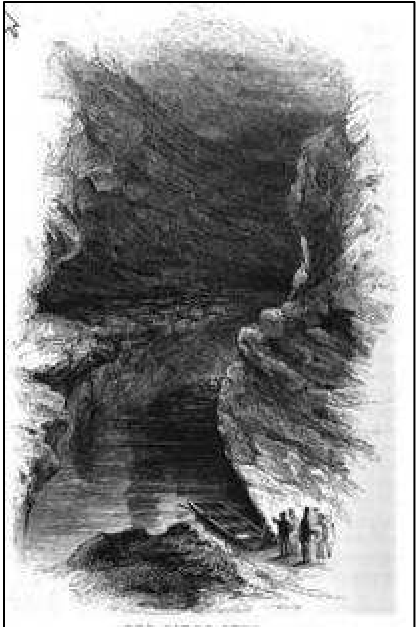
> *The rippling of the water caused by the motion of our boat is heard afar off, beating under the low arches and in the cavities of the rocks. The report of a pistol is as that of the heaviest artillery, and long and afar does the echo resound, like the muttering of distant thunder. The voice of song was raised on this dark, deep water, and the sound was as that of the most powerful choir. A full band of music on this river of echoes would indeed be overpowering.*

"Notes for a Tourist" in the December 5, 1846, Scientific American admonished a visitor from abroad,

> *Madam, you should have been born in America; the greatest country in the known world; nature has clustered all her stupendous and dazzling works upon this land... Madam go and see the falls of Niagara... Then, madam, you should go and see the great cave in Kentucky... If you go back to England without seeing our mammoth cave... you'll leave a pretty big hole in the book you're going to write.*

Here's what Horace Martin had to say about the subterranean boat ride in Pictorial Guide to the Mammoth Cave, Kentucky (1851).

> *At the foot of the slope the River Styx winds its way. It is aptly named: people might well imagine it to be the fabled stream whose name it bears. Four passengers only can be conveyed over this river at the same time. The guide fastens lamps at the prow of the boat, and the various images are reflected in the murky pool.*



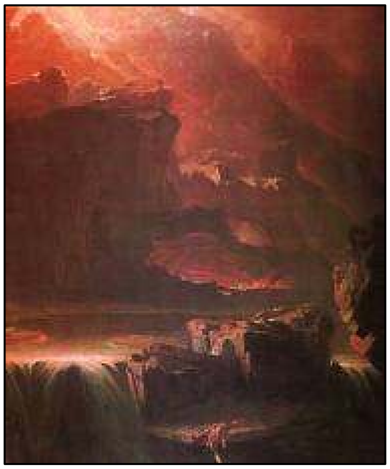
Still a four-passenger boat in the Styx, 1851.

> *There is another mode of crossing the Styx. It is by means of a bridge overhead, composed of abrupt precipices. To avail himself of this bridge, the tourist must ascend a very steep cliff, then enter a cave above, three hundred yards long. Leaving this, he will find himself on the bank of the river, more than eighty feet above its surface. He will then command a view of the persons who are in the boat, and also of those upon the shore. The lamps in the canoe, when viewed from this distance, have a singular and striking appearance. Their glare is that of gigantic eye balls.*

The craft, not a "canoe," but a three-benched punt, is to the left of the visitors.

Martin continues,

> *The Styx is the smallest river in the Mammoth Cave. Having passed it, the visitor walks over a pile of large rocks, and finds himself on the banks of the Lethe. Here, again, will be found a striking resemblance between natural objects and the names given them. How striking is forgetfulness typified in that river! We remember seeing many years ago a picture of the Waters of Oblivion, painted by John Martin, which, in its general details, in the tout ensemble, might have been taken as a representation of this cave-stream and the objects which surround it.*



For reference, to the right is John Martin's (no relation to Horace, as far as we know) "Waters of Oblivion" (1812).

> *Looking back, the tourist will perceive a line of men and women descending the high hill from the cave, which runs over the River Styx. Two boats are kept, and the parties who have come by the two routes -- that is, either down or over the Styx, may unite and descend the Lethe about a quarter of a mile.*
>
> *The boats used here are capable of carrying twelve persons each.*

📋 Two 12-passenger boats on the Lethe, 1851.

Martin notes a propensity for apprehensions.

> *The River Echo is about three miles in length. There is a rise in the water, of only a few feet, through which the three rivers are united. When there has been a long succession of heavy rains, these rivers sometimes rise to a perpendicular height of more than fifty feet, and, with the cataracts, exhibit an aspect of awful grandeur. When the rise of the water does not extend even beyond two feet, the low arch at the entrance of the Echo cannot be reached by the visitor. Occasionally, great apprehensions have been felt by the tourists, in consequence of their being caught on the opposite side, by a sudden rise; but the guide has considerately informed them of an upper cave, admitting of a passage, leading round the arch to the Great Walk.*

And adds a brief sermon.

> *The passage down the river is replete with pleasure and interest... Powerfully, most powerfully is the benign mandate of Christ, for those whom he redeemed to live in love and peace with one another, impressed here. Nature, in her aspects of beauty, magnificence, and solemnity, is a mighty illustrator of Him whose work she is; and there are thousands of instances of her power to improve or purify those on whom both oral and written precepts have had no power. May we not believe that the stream of Lethe in this Mammoth Cave of Kentucky, had it a voice, could tell us of such changes, wrought on its bosom or its banks, in the souls of many a visitor?*

From "A Visit to the Mammoth Cave," New York Times, August 12, 1858,

> *We pass along, hear the roar of invisible waterfalls; and, at the foot of the slope, the River Styx lies before us, deep and black, over-arched with a rocky bridge, which we cross.*
>
> *Another descent brings us to the River Lethe, where we embark on a flat-bottomed boat, and ride for a quarter of a mile, in a river with a gentle current, being propelled by the guide, who pushes with a pole either against the bottom of the river, or else the arched roof of the cave, which, in some places, we can reach with our hands.*
>
> *We disembark, and commence an ascent over a short distance on the Grand Walk; which, though somewhat damp, resembles its name, and in size is a little like the main cave. A few hundred yards brings us to Echo River, where again we embark on water without much current, but beautifully arched, and reverberating the sounds of our voices with sonorous cadences.*
>
> *These rivers rise an fall with Green River, and therefore communicate directly with it; hence we infer that the cave at this point is very near that river... But this is mere conjecture, as the proprietors will not accurate survey to be made.*

The last sentence helps explain why the hydrology remained inconclusively documented for decades to come. Take, for example, "The Plankton of Echo River, Mammoth Cave," Transactions of the American Microscopical Society, May 1900, by Charles A. Kofoid.

> *Barometric observations indicate that the level of Echo River is about twenty feet above that of the local surface stream known as Green River. Experiments with floating chaff have demonstrated that the subterranean water system of Mammoth Cave opens in certain large springs along Green River.*

We must add chaff to our tracer list in Chapter 46. Only in 1909 did Max Kaemper, a German mining engineer, produce an accurate instrumental survey of the caverns. But again we've diverted from the chronicles of Mammoth Cave boating.

In reviewing subterranean shipwrecks in Chapter 65, we'll mentioned a near disaster in Mammoth in 1904. Reflection on this event in the New York Times, January 19, 1904, is more about the English language than tourism, but it provides us a story from 1859.

> *Reading of the fatal accident to several people in Mammoth Cave recently recalls a similar incident that occurred to the writer in 1859, who was one of a party of four, besides the guide,*

> *to make the long tour, as it was called then. We embarked in the boat, a flat one, when the river was high and rising. The guide said he thought we could get through, and upon his assurance we undertook it. But the river was higher than he had expected, and we had difficulty in getting through. In the lowest part of the roof we had to lie flat upon our backs in the bottom or the boat and push down stream as hard as we could, the top of the boat scraping the roof of the cave for some distance before we finished the boat ride.*
>
> *It didn't seem to me that the roof was more than fifteen or twenty inches above the surface of the water. We didn't realize the danger until it was over, and we shuddered at the narrow escape we had had. In returning, the guide took us by another route, by which we avoided Echo River.*
>
> *One of the tourists was taking notes, saying he was going to "write a book" about it. At a place called Elbow Crevice he wrote Elbow Crevis. In passing over the Bridge of Sighs, the guide said he didn't know unless because it was of such size. Another stream was called River Styx. Our literary associate wrote "Sticks." He showed me his notes -- or I wouldn't have known of his particular orthography.*

The New York Times, September 7, 1868, featured "The Mammoth Cave, Pleasures and Pains of Western Travel... -- A Woman's Experience Under Ground -- The Mammoth Cave from an Unromantic Point of View" by Calhoun Richards

> *Exultingly, I produced my guidebook, and read to him the descriptions -- so graphic -- of the "Methodist Church," the "Grant's Coffin,"... and more than all, of a beautiful limpid stream misnamed the "River Styx," oh whose shore were tiny, smooth pebbles -- pebbles which we would gather for our loved ones, in memory of this cave visit.*

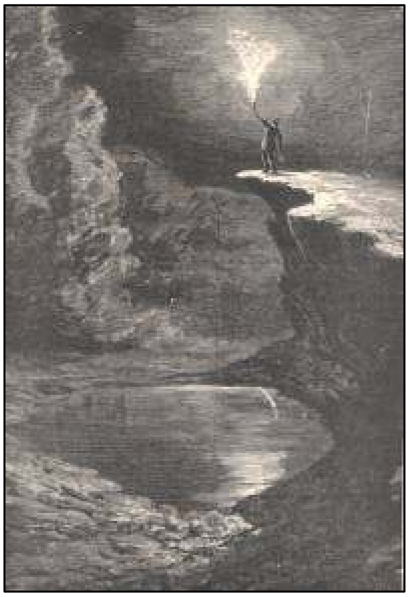
An excerpt from The Mammoth Cave and its Denizens: a Complete Descriptive Guide (1869) by Adam Binkerd begins with Charon.

> *Passage over the Styx. In mythological times, Mr. Charon seemed to monopolize the ferry business, and so unpopular did be become that no one patronized his ferry, except under protest, and I believe to this day there may be found plenty of tourists who would rather swim the Styx: than step into the old curmudgeon's boat. Happily we are not left with this alternative, for we have a natural bridge spanning the Styx in the cave, and over this, parties usually pass, without paying any toll.*
>
> *The Embarkation. Thick, dreary darkness is before and behind us; the dark gray rocks on each side and over us, and at our feet lies a pool of water, whose surface never rippled by the breeze, looks calm as the face of an honest man in deep meditation. Moored by a stake driven into the sand, is a little boat, narrow, short, and shallow. This is the craft in which we entrust our most sacred treasure for a voyage over the Lethe. Shall we risk the voyage? Why not?*

Why not, indeed!

> *We step into the boat, freighting her down within a few inches of her bearings. The guide now plies the paddle steadily, and skillfully, for we are entered upon a new field of explorations. The lights in the prow cleave the thick, murky darkness that closes around behind us, as the waters close around a fish. As we strain the vision to look out into the dismal realm, like a wrecked mariner looking out for a friendly sail, or for land, an impressive feeling creeps over us and we meditate upon the singular relation we sustain toward the world and ourselves. We are afloat upon a river that the sun never shone on, far beneath the surface of the earth, and in the enjoyment of life, health and reason, and -- yet cut off from all communication with the outer world, except through the medium of the little boat and our lamps.*

From America Illustrated (1883), edited by J. David Williams,



> *On the left of the cave is a steep precipice, over which you can look down upon the black waters of the Dead Sea eighty feet below. At the foot of the slope flows the River Styx, and in that stream and the Echo River are found the eyeless fish. Beyond the Echo River there is a walk of four miles to Cleveland Avenue, a passage three miles long, seventy feet wide, and ten or fifteen feet high, beyond whose termination no explorers have passed.*

From Kentucky, A History of the State (1887) by William Henry Perrin, J.H. Battle and G.C. Kniffin and plagiarized, almost verbatim, in the 1911 Encyclopedia Britannica,

> *The waters entering through numerous domes and pits, and falling, during the rainy season, in cascades of great volume, are finally collected at River Hall, where they form several extensive lakes or rivers, whose connection with Green River is known to be in two deep springs, appearing under arches on its margin. Whenever there is a freshet in Green River the streams in the cave are joined in a continuous body of water, the rise being sometimes sixty feet above the low water mark. The subsidence within is less rapid than the rise; and the streams are impassable for about seven months in each year. They are navigable from May to October, and furnish interesting features of cave scenery.*
>
> *The first approached is called the Dead Sea, embraced by cliffs sixty feet high and 100 feet long, above which a path has been made, whence a stairway conducts us down to the banks of the River Styx, a body of water forty feet wide and 400 feet long, crossed by a natural bridge. Lake Lethe comes next, a broad basin, enclosed by walls ninety feet high, below which a narrow path leads to a pontoon at the neck of the lake. A beach of the finest yellow sand extends for 500 yards to Echo River, the largest of all, being from twenty to 200 feet wide, ten to forty feet deep, and about three quarters of a mile long. It is crossed by boats*.

Question 120 from Queer Questions and Ready Replies: A Collection of Four Hundred Questions in History, Geography, Biography, Mythology, Philosophy, Natural History, Science, Philology, Etc., Etc., with Their Answers (1887).by Samuel Grant Oliphant,

> *Where is there an underground river in the United States?*
>
> *There are two underground rivers -- the Echo and the Styx -- in the Mammoth Cave, Kentucky. The Echo is about three fourths of a mile long, two hundred feet wide at some points, and from ten to forty feet deep. It is crossed by boats. Its course is beneath au arched ceiling of smooth rock, varying in height from ten to thirty-five feet, and famous for its musical reverberations; not a distinct echo, but a harmonious prolongation of sound for from ten to thirty seconds after the original tone is produced. The long vault has a certain key-note of its own, which, when struck, excites harmonics, including tones of incredible depth and sweetness. The Styx is much smaller than the Echo. It is about four hundred and fifty feet long, from fifteen to forty feet wide, and from thirty to forty feet deep. It is spanned by an interesting natural bridge about thirty feet above it. Both these streams have an invisible communication with Green River, the depth of*

> *the water and direction of the current in them being regulated by the stage of water in the latter stream.*

From "Mammoth Cave, Kentucky," Journal of the American Geographical Society of New York 23, 1891, by Horace C. Hovey,

> *A flotilla of uncouth little flat-boats is kept on the river, some at one end and the remainder at the other, the materials for which were all brought in through the Fat Man's Misery, being afterwards put together. It is a fine spectacle to see eight or ten boats, each carrying from ten to twenty passengers, with an ample supply of lamps, and an occasional discharge of fireworks, following each other, their crews meanwhile tempting the marvelous echoes by shout, scream and song, laughter, whispers and yells, rattling pistol shots, flute solos and bright arpeggios on the cornet -- all of which are faithfully reproduced, though occasionally with remarkable variations.*

📋 Eight or ten 10-20-passenger craft on the Echo, 1891. Twenty's as big as the boats would get.

From the comprehensive Mammoth Cave of Kentucky, An Illustrated Manual (1897) by Horace C. Hovey and Richard E. Call,

> *A fleet of flat-boats awaits us on Echo River. These boats are built of planks and timbers brought in by way of the Crevice Pit and Mammoth Dome; though formerly every piece had to come in by the Fat Man's Misery. When not in use the fleet is moored by chains, though grapevines were used at the time of our first visit. Ropes are not strong enough to hold the boats in time of flood. A stray boat lies stranded below Gorin's Dome. How did it get there?*
>
> *Each boat has seats on the gunwales for twenty passengers, who set their lamps down in a row in the middle of the craft.*

📋 Twenty-passenger vessels, 1897.

> *The guide stands in the bow and propels the boat by a long paddle, or by grasping rocks projecting from the ceiling. Usually but a slight current is to be noticed. Hence the singular inaccuracy of an imaginative picture by a French artist that has been extensively copied, representing the river as boisterous, and frantic oarsmen striving with might and main to keep the boat from shipwreck on the rocks. And as the only gale here is that which blows out from the mouth of the cave, there is equal absurdity in a striking picture that shows sail-boats on this calm and unruffled tide.*

And still citing Hovey and Call's Mammoth Cave of Kentucky,

> *While speculating as to cascades, mushrooms, and blind fish we were startled on the occasion of our first visit by hilarious sounds that heralded the approach of another party. There never was a prettier sight than this merry company when they finally emerged from the darkness, sixty in all, with flashing lamps and spangled costumes. They wound past us along the somber terrace, astonishing the gnomes by their jolly shouts and jovial songs. On they went, single file, behind a wall of stone, to come into view again on a natural bridge over the River Styx. The details of the wild scene were brought to light as they swung their lamps in order to catch sight of the mysterious banks on which we stood below them.*

The "French artist" is most likely Gustave Doré, whose engravings for Dante's Inferno we inspected in Chapter 33. We'll see the image again in our stamp collection, Chapter 56.

> *There are three arches, through either of which we may launch on Echo River. The first arch is only about three feet above low water, and if the river has risen a little, it is necessary to go on to the second, or even the third arch. In doing this we cross the Sandy Desert and flounder through a muddy place named Purgatory. As has already been stated, there is a current of varying strength when the river rises above low water mark. The last time we were there we undertook the voyage at some peril, and the guide made no use of his paddle, relying wholly on the current and his pointed staff to take us through. The next day the river was wholly*

> *impassable. But great care is taken by the guides, and we have never yet heard of any mishaps on the rivers.*

Mishaps, of course, indeed had occurred, but such tales wouldn't encourage tourism. The guidebook marches onward.

> *The estimated length of the River Styx, whose black waters wind their way between the steep walls and underneath the bridge, is about four hundred feet, and its breadth is not far from forty feet. Formerly it had to be crossed by boats, but now it is done by the natural bridge just mentioned. The spot was dangerous before a guard-rail was erected. Among the thrilling stories told of cave adventures is that told by William, the guide, of Professor Silliman's slipping from the bridge. The savant would have fallen into the Styx had not the brave guide sprung to the rescue.*
>
> *On descending from the bridge we enter a lofty and spacious hall, where we find the placid waters of Lake Lethe, a body about as large as the Styx, and which was also formerly crossed by a boat. It is now partly filled with debris, allowing the construction of a narrow path along its margin to the pontoon that bridges its neck.*

A debris-filled pond is safer to cross.

From "The Mammoth Cave of Kentucky," The Century, March 1898,

> *We pass along the narrow pathway on the edge of the dark cliffs overhanging the Dead Sea. The lights, skillfully thrown on projecting ledges on the farther side, are inadequate to dispel the darkness surrounding the clear pool of water below. We stop to listen to the musical splashing of a small cascade. We cross a stone archway forming for hundred feet a natural bridge over the River Styx. We stamp upon the hollow stone to hear the drum-like sounds reverberating through the avenues. We pass in single file along the side of Lake Lethe, and enter the Great Walk, a lofty, spacious avenue about 90 feet high, extending for about 1200 feet to the shore of Echo River. The floor of this lofty avenue is a clear, yellow sand. When the river is high this walk submerged, thus adding to the width of the river. For a long time Echo River barred the way to the extensive system of avenues beyond. The celebrated colored guide Stephen Bishop was the first to cross it. New avenues have been discovered and opened up, so that it is now possible to reach the trans-river portions of the cave without crossing the river. But these are used only when the river is too high to cross, as a sail on this underground water is one of the most delightful experiences of the cave.*
>
> *Flat-bottomed boats, each with a capacity to carry about twenty persons, have been provided.*

📋 Again the 20-passenger boats, 1898.

> *Our lamps are arranged at each end; we take seats along the sides of the boats, which are pushed off; and we silently float out under the dark archway into an unknown world such as we have never before conceived of. The river is about 20 feet deep, of the purest water, so clear that pebbles can be seen on the bottom. In places it widens out to 200 feet, and branches reach away into darkness on each side. It is a sail of about three fourths of a mile to reach the farther shore, and it is an experience ever to be remembered.*
>
> *Our guide asks us to keep silent; then, lifting the heavy, broad paddle with which he has been propelling our boat, he strikes with all his strength the flat side on the surface of the water. Instantly the subterranean thunders of this under-world are let loose. From all directions come rolling waves of sound multiplied a thousand fold, receding, and again returning with increasing volume, lingering for many seconds, and finally dying away in sweet, far-away melodies. Then, when the last faint sounds have ceased, he agitates the water with his paddle, and asks us to listen. The recoding waves, reaching cavities in the side soft be overhanging arches, break the stillness with sweet boll-like sounds. Some notes, striking the keynote of the rocks, multiply the musical melody; some notes are soft and low; others are loud, almost with an alarm bell clangor. This music, such as can not be heard elsewhere on earth, gradually dies away in receding echoes, coming over the, waters from far-away hidden chambers. The echo is not*

> *such as we hear above ground or in buildings, but a succession of receding waves of sound, lasting for about thirty seconds, and adding an indescribable melody to all sounds, whether from shouting or from instrumental or vocal music.*

And from The Nation, August 25 of that same year, "Our Subterranean Echo River Surpasses Them All,"

> *But the greatest curiosity of the longer route is the Echo River, which is navigated on flat bottomed boats for about twenty minutes. The Cave here is very low -- the first arch under which the boat goes being only two feet and a half above the level of the water ordinarily -- but after a while it rises a little and provides a vault which has what Is probably the most beautiful echo in the world.*
>
> *The river was very gentle and pleasant while we were on it, but the guide said that sometimes, when there are heavy rains outside, Purgatory is changed from a great dry hall to the bed of a rushing torrent, in which it is difficult to prevent the boat from being dashed against the rock. It is only quite recently that the source of this water has been traced to the Green River; where it flows is not yet known.*

As we now know, the Echo is tributary to the Green River, not the other way around, but the readers wouldn't have cared.

> *The guide sings an arpeggio (three or four successive tones, say G, B, D, G up, or G, E, C, G down) and, thanks to the duration of the echo, these four tones reach the ear as a rich and perfect chord of simultaneous sound. Still more beautiful is a higher arpeggio sung by a woman's voice. The sounds seem disembodied and etherealized, like those of an aeolian harp, and the effect is as, thrilling as the three choruses, one above the other, in "Parsifal."*
>
> *Europe has the Sistine Chapel and some acoustically remarkable cathedrals, but our subterranean Echo River surpasses them all. After the beautiful, we had an exhibition of the sublime in sound. A Kentuckian in our boat fired a revolver. The sound which, in the open air, would have been like the transient crack of a whip, here reverberated with a deafening boom, like the roar of great peals of thunder, lasting fully a minute.*

"Europe has the Sistine Chapel and some acoustically remarkable cathedrals, but..." What better could express the confidence of a burgeoning nation?

From Mammoth Cave, Kentucky: An Historical Sketch Containing a Brief Description of Some of the Principal Places of Interest in the Cave (1909) by John Thompson,

> *The dismal waters of the "Dead Sea" presently come to our view. This pool, for such it is, lies far below us, and it is well named. There are few gloomier places than this to be found anywhere. One feels as if he were groping' through the abode of evil spirits, souls that are forever cut off from the light. "River Styx" and "Lake Lethe" are the next two points of interest. At the time we made our trip the rivers were low, but on some occasions in the fall and winter the waters are much higher. We are now rapidly approaching the wonderful subterranean stream appropriately called "Echo River." Here one can ride for about half a mile on flat-bottom boats, and it is an experience never to be forgotten. When we get to the river we find three large boats moored along the rocky shore. Our guide directs us to step in one of the boats and seat ourselves, an equal number on each side. In a few minutes we are silently floating down the river. The charm of this river is its marvelous echo, and still it can hardly be called an echo in the ordinary sense of the word, for when slowly singing "My Old Kentucky Home," "The Old Oaken Bucket," or other familiar ballads, a single voice will begin to sound like an orchestra. The wonderful turns and curves in the cave around us has, no doubt, a subtle effect upon any sound that may be produced here, and as the last words of the singer cease, we sit enraptured listening to the sweet seraphic sounds dying away in the uttermost parts of the cavern.*

In "Luray Caverns and Mammoth Cave," See America First (1922), Orville O. Hiestand paints a equally-melodramatic picture.

> *You never can forget your trip on this river of Stygian darkness. With oil lanterns that emit but a feeble flickering flame you see ghostlike figures, goblins and grim cave monsters that loom before you; your imagination peoples these subterranean halls and their titanic masonry with fantastic forms of its own creation.*

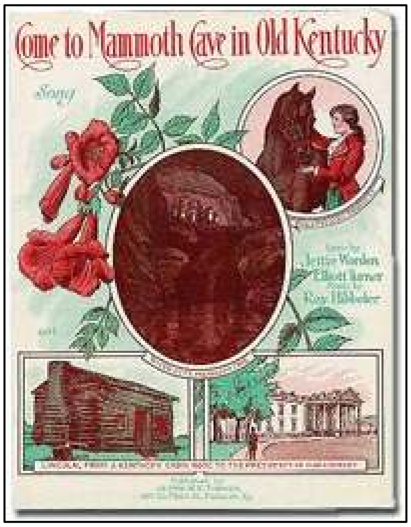
Ah, for readers who appreciate English!

While the reports portray a sense of ribaldry, for those preferring melodies more inspirational, we have "Come to Mammoth Cave in Old Kentucky," (1921) lyrics by Jettie W.E. Turner.

Chorus

On Echo River you sing song after song,
  My Old Kentucky Home you've loved so long.
Nearer My God to Thee
  Learned at mothers knee,
Sweet Bye and Bye,
  Echoes back to thee.

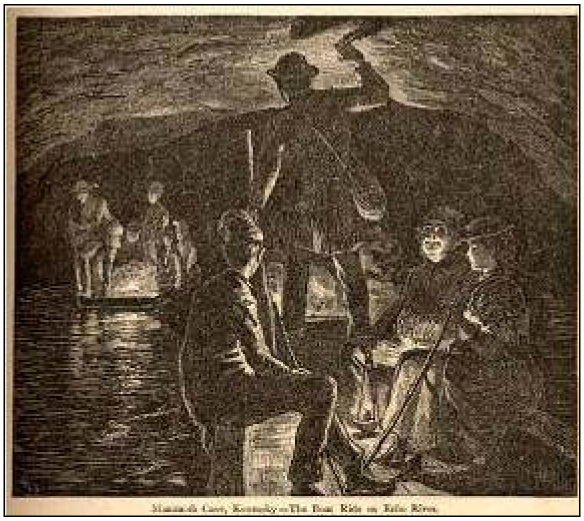
The oval picture is one of visitors peering into the waters.



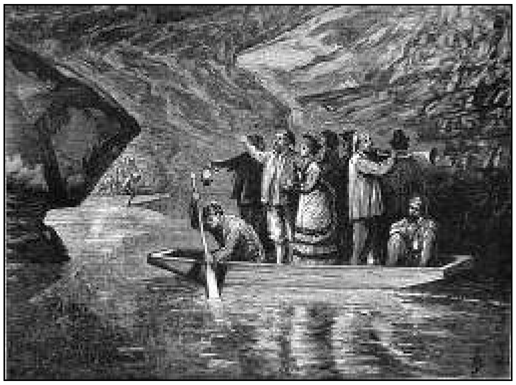
The voice of song, flute solos, bright arpeggios on the cornet, jovial songs, paddle slaps, arpeggios, revolvers! The Echo River seems to have been named appropriately.

An Illustrated Chronicle

As we've seen, all three Mammoth Cave waterbodies were traversed in vessels that were up-sized over time. The Styx was but a ferry ride; the Lethe and Echo were excursions. Here's a scrapbook of on-the-Echo pictures, penny-postcards for the large part.

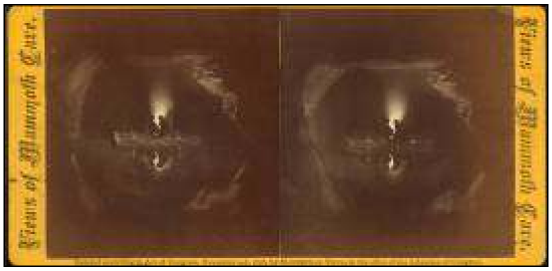

Mammoth Cave, Kentucky—The Boat Ride on Echo River.

1875

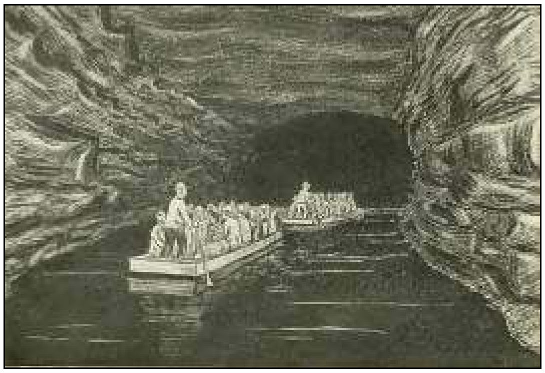


1876

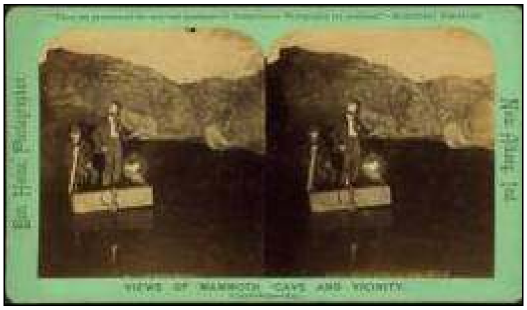
Note the trumpet


Views of Mammoth Cave.
Views of Mammoth Cave.

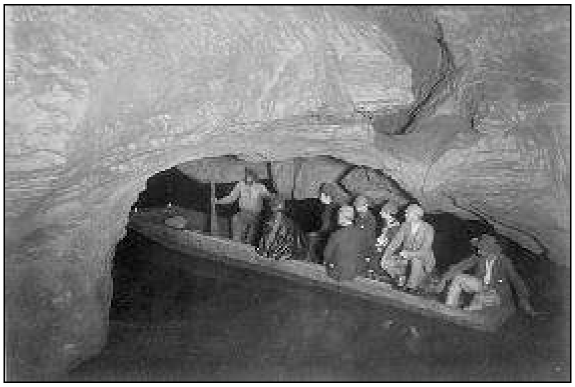
1887



.1887


VIEWS OF MAMMOTH CAVE AND VICINITY

1889



1891

1893

1900

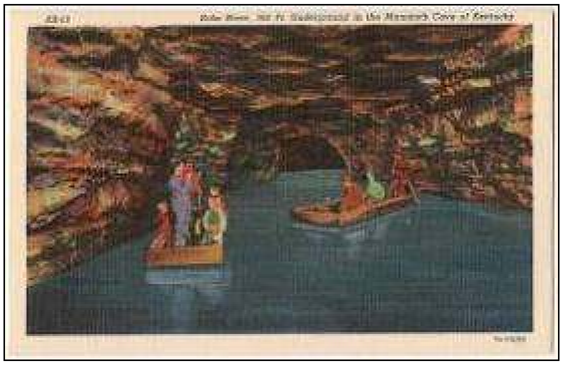
1900

The next four photos we include to illustrate photographic doctoring.

1908

ECHO RIVER, MAMMOTH CAVE, KENTUCKY.

1911

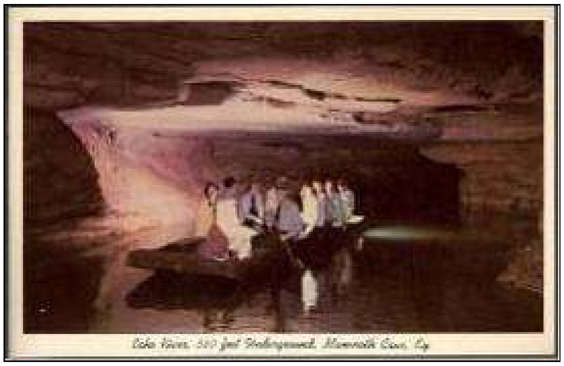

Echo River, 360 ft. Underground in the Mammoth Cave of Kentucky

1915

1920

On Echo River, Mammoth Cave, Ky., 360 feet underground.

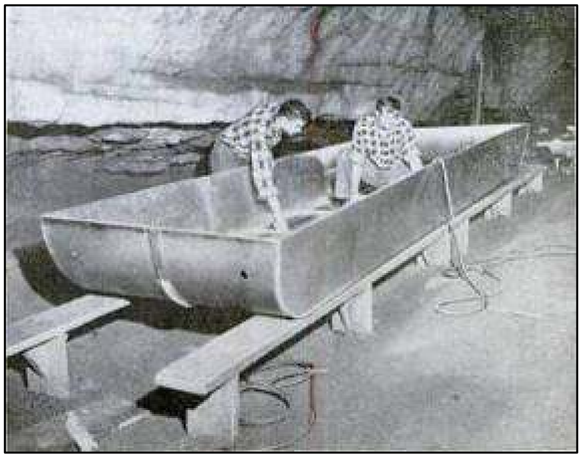
Echo River - In Mammoth Cave - Mammoth Cave Nat'l Park, Ky.


Echo River, 360 feet Underground, Mammoth Cave, Ky.

1956

From "Underground Cruiser Assembled in Cave," Popular Mechanics, May 1960,

> *Too big to be carried to the depths of Mammoth Cave, Ky., in one piece, a 20-foot aluminum cruise boat had to be taken to the 300-foot level in preformed sections. There it was assembled by riveters on the bank of the Echo River. The big boat has a 54-inch beam, is 15 inches deep, and will carry up to 20 visitors at a time on underground river cruises.*



For environmental reasons, however, the rides were discontinued in the 1990s, but one can still tour the cave riverbanks by foot. To the right is today's boat-free Echo River.

Historic Echo River
$12.00

Information regarding the River Styx tour:

> *Trace the stages of cave development from solid layers of limestone to the world's longest known cave system. Follow the course of water from ridge top to river bottom and witness the persistence and power required to create this geologic marvel.*

River Styx
$13.00

Duration: 2 hr. 30 min.
Distance: 2.5 miles
Number of Steps: 560
Effort: Moderate
Elevation change: 360 feet
Low light in river passage
No restrooms available

> *Visitors with known heart or respiratory problems, poor circulation or difficulty walking long distances and negotiating stairs, should carefully consider their limitations. Evacuation from the*

> *cave to a hospital for medical attention could take several hours. If you have a fear of heights or suffer from claustrophobia, this tour is not the best choice for you.*

As for Jenny Lind's (Chapter 36, Underground Rivers in Sound and Song) visit, the underground river ride was not to be.

> *They were all well and in raptures with that portion of the Mammoth Cave which they had been able to see -- the river which crosses the cavern having been too swollen to give them opportunity of passing it.* -- Charles Rosenberg, Jenny Lind in America (1851)

Steamboating

Americans -- perhaps especially those of the 19th century -- have rarely been short on ambition.

From Rambles in the Mammoth Cave, During the Year 1844, by A Visitor (1845), which we have cited earlier,

> *The Echo is truly a river: it is wide and deep enough, at all times, to float the largest steamer.*

From another already-cited work, Horace Martin's Pictorial Guide to the Mammoth Cave, Kentucky (1851),

> *The Echo is a bona fide river -- wide and deep enough, we believe, to float a steamship as large as the "Atlantic" or "Pacific."*

From "The Mammoth Cave of Kentucky," The Experiment, September 5, 1894,

> *Boats are in readiness for those who feel inclined to take aquatic excursions on the river, and Bengal lights can be had by such as which to witness the sublime spectacle, which is exhibited by an illumination of the various domes.*
>
> *The river is three miles from the mouth of the cave. Where you first strike it, it is not very wide, but of great depth; as you descend it, it becomes wider, and has a gentle current... Mr. Gorin, a highly respectable lawyer and a former representative of Warren Co., informed me that there is a sufficiency of water in this river to float the largest class of steamboats.*

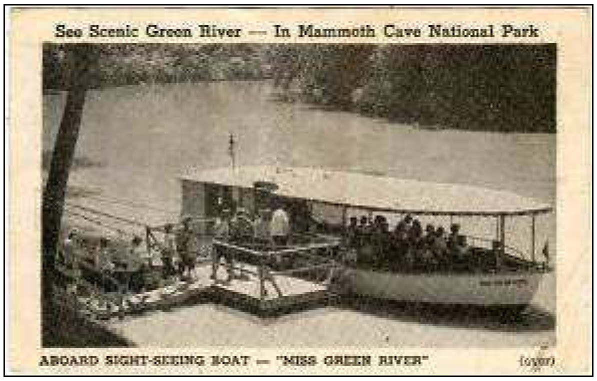
Getting the vessel to the water, much less, fitting it in, were insurmountable problems, but at least one might use a steamship to get to the cave.

After completion of Green River Lock and Dam Number Six in 1906, just downstream from Mammoth Cave, the steam packet Chaperon ran Green River sightseeing excursions during the summer months.

The most popular excursion was a 10-hour run from Bowling Green to the cave followed by a return trip by rail. The steamboat era ended in 1917.

The Mammoth Cave Train

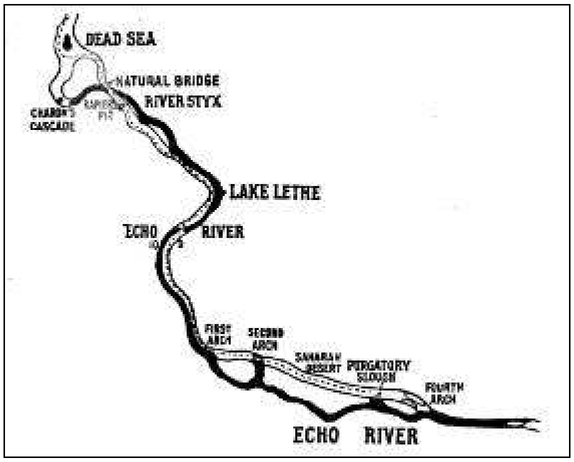
As the steamboat plied the Green River to Mammoth Cave, not the Echo River within the cavern, the subterranean prognostication remained unrealized, however. The paddleboat tour was to persist -- but just for the topside -- until Miss Green River II retired in 2007.

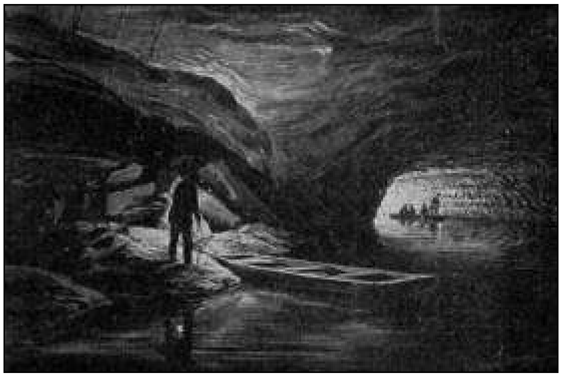

See Scenic Green River — In Mammoth Cave National Park
ABOARD SIGHT-SEEING BOAT — "MISS GREEN RIVER"

Miss Green River I

Miss Green River II

Cave-explorer Edouard Martel (the subject of the Chapter 49) toured Mammoth in 1912, even then heralded as the "World's Longest Cave," but visited only those parts accessible to tourists per H.C. Hovey's Hand-Book of the Mammoth Cave (1909), the river portion of Hovey's map shown below.


DEAD SEA
NATURAL BRIDGE
RIVER STYX
CHARON'S CASCADE
LAKE LETHE
ECHO RIVER
FIRST ARCH
SECOND ARCH
SAHARAH DESERT
PURGATORY SLOUGH
FOURTH ARCH
ECHO RIVER



Martel/Echo River illustration
by Lucien Rudaux

As lamented in "Explications sur Mammoth Cave," Spelunca 74, 1913, Martel was less than impressed.

> *Echo River, which has been given this name because of its phenomenous resonance, has received too much praise by cave authors. It is nothing but a black passage with a flat, low ceiling and walls that floods have covered with mud. In short, it completely disillusions someone who has passed the rivers of Padirac, Betharram, Labouiche, Adelsberg, etc. When Hovey writes: "The subterranean world has nothing to compare with the River Route," he certainly has not seen any really beautiful underground rivers yet. The width of Echo River varies between 6 ft. and 60 ft. Almost everywhere you can reach the ceiling with your hand.*

And with that note -- what one might expect from a Frenchman who's ventured where danger is genuine -- we'll move on to other underground rivers.

CHAPTER 51

THE TOURIST TRADE WORLDWIDE

Remouchamps
Caves, Belgium
€11.00

Since Charon charged the coins, there's been money to be made on underground rivers and the manifest most profitable is tourists.

Transition from exploration to commercialization can be prompt. Improve an entrance, add a boat and some illumination and the underground stream can earn much more than two obols.

We've an example of the transition from the French Pyrenees, the Labouiche underground river explored by Martel (Chapter 49, Subterranean Watercraft) in 1908. Commercial efforts were underway a year later while an expedition of nine persons and five boats was yet probing further into the cave. From My Caves (1947) by Norbert Casternet, one of the explorers,

> *We passed a working party of electricians in a boat, fixing insulators to the walls. The sudden appearance of two people sailing along on two rubber rafts with a torch in their helmets was such a novel and unexpected sight that they stopped working and would have watched us go by in silence if we had not spoken.*
>
> *It gave me an odd feeling I had never had before to pass this party working to make a cave accessible tourists while we went on to wage a battle, to match our skill and strength against the unknown difficulties that suddenly confront those who push their exploration further and further into the bowels of a mountain.*

The tourist trip today on the Labouiche includes a 1.5 kilometer boat ride. About 4 kilometers of the river are accessible.

Labouiche
€7.40

Here are a few more operations and their prices of admission, beginning with two in Homer's territory.

Continental Europe

The Pirgos Dirou caverns in Peloponnesus are thought run about 70 kilometers, of which tourists can travel 1.3 by punt. The River Glifada flows from the cavern to the sea at 0.5 cubic meters/second. The caves have yielded human bones from the Paleolithic and Neolithic eras.

Pirgos
Dirou
€15.00

Underground Lake Melissani was discovered on the Greek island of Kefalonia when the roof collapsed after a 1953 earthquake.

The cave is 40 meters wide and 20 to 30 meters in depth. A tunnel allows small boats to carry visitors. Artifacts have been dated to the post-classical and early Hellenistic periods, third and fourth century BC.

Melissani
€6.00

For a gloomy Victorian outing, one could have enjoyed "A Walk Through a Mountain," or more accurately, a tour of an Austrian mine, courtesy of Living Age, April 16, 1853.

> *Our guides lighted more candles, and we began to see their rays reflected from the water; we could hear too the dull splashing of the boat, which we could not see, as old Charon slowly ferried to our shore. More lights were used; they flashed and flickered from the opposite ferry station, and we began to have an indistinct sense of a spangled dome, and of an undulating surface of thick, black water, through which the coming boat loomed darkly. More candles were lighted on both sides of the Konhauser Lake, a very Styx, defying all the illuminating force of*

> *candles, dead and dark in its dim cave, even the limits of which our lights did not serve to define. The reached our place for embarkation, and we, wandering ghosts, half walked and were half carried to the clumsy hulk, and took each his allotted seat in ghostly silence. There was something really terrible in it all; in the slow funereal pace at which we floated across the subterranean lake; in the dead quiet among us, only interrupted by the slow plunge of the oar into the sickly waters. In spite of all the lights that had bee kindled we were still in a thick vapor of darkness, and could form but a dreamy notion of the beauty and the grandeur of the crystal dome within which we men from the upper earth were hidden from our fellows. The lights were flared aloft as we crept sluggishly across the lake, and now and then were flashed back from a hanging stalactite, but that was all. The misty darkness about us brought to the fancy at the same time fearful images, and none of us were sorry when we realized the other shore in safety.*

Rediscovered in 1813, Grottes des Planches lies within the French Jura. Most of the cave passages were flooded until 1935, when the water level was lowered by digging a channel between the Grand Amphitheatre and the outlet.

Rivière Souterraine, 1930

Grand Amphitheatre

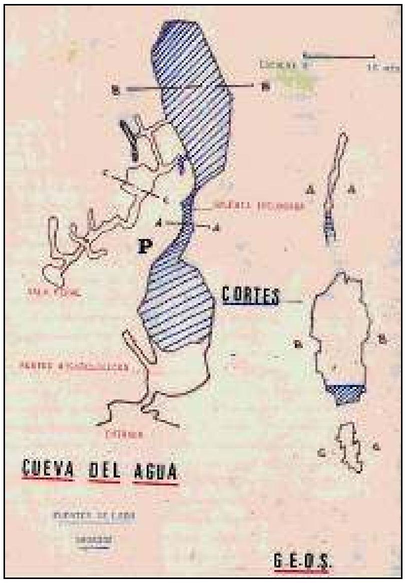
Today's cave museum contains a wooden boat used to develop the cave, but the modern visitor is confined to walkways, the first portion attached to the cave wall high above the water. Where the passage narrows, the walkway is only one or two meters above the water, and further within, the path is only a bit above the river bed and floods after heavy rains.

Grottes des
Planches
€8.50

Punkva Cave in the Czech Republic was first described in 1723. Visitors now navigate three subterranean lakes to reach the Pohádkový dóm. Columns, curtains and cascades of stalagmites and stalactites in alternate with transparent straws and nodulated carrot-like formations called “helictits."

Punkva
CZK 160

A 1920s photo from the Caves of Fuentes de León in central Spain, a map and a graphic from the modern visitor center.


B
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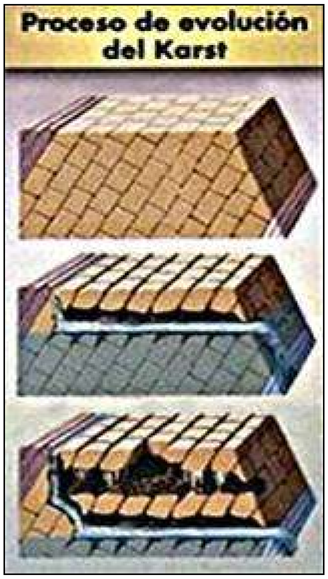
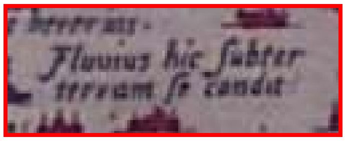
CUEVA DEL AGUA
G.E.O.S.


Proceso de evolución del Karst

We have, however, much earlier documentation, a 1570 map of the Iberian Peninsula, "Regni Hispaniae Post Omnivm Editiones Locvpletissima Descriptio," A Very Reliable Depiction of the Kingdom of Spain after the Publications of Many [Authors], containing this inscription



"Fluuius hic subterterram se condit" -- Here the river flows underground.

Here's some period travelogue from Earth and Sea, from the French of Louis Figuier (1870) by William Henry Adams regarding the Grotto de Han in Durbuy, Belgium.

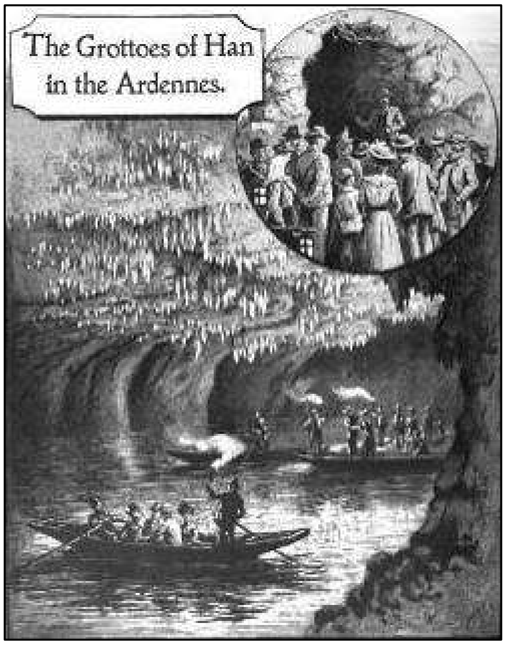
> *The concluding part of the journey is performed in a boat, whose oarsman gently propels it with his sculls, while the visitor surrenders himself for a few moments to the emotions which agitate his soul. The guides toss to and fro their resinous torches; they kindle wisps of straw, and their mingled flames reveal a semiogive roof, semi-horizontal, formed, as it were, by two huge blocks of stone throughout its entire length, and embellished with a profusion of glittering stalactites.*
>
> *Slowly, slowly does the little skiff drop down the murmuring stream. The deep intense silence which prevails in this mysterious under-earth is only interrupted by the shrill cry of bats, by the monotonous babble of drops of water which, falling from the roof, drip, drip, drip into the river, and by the incessant bounds and somersaults of the fish attracted to the surface of the water attracted by the wavering light.*

It seems the grotto had cave fish, a subject with which we are familiar from Chapter 47, Wrecks of Ancient Life.

From "Some Wonderful Caverns -- The Grottoes of Han in the Ardennes," The Chatterbox (1905) by Helena Hays,

> *A narrow opening high on an oak-covered hill; A cluster of women, girls, and boys, each carrying a slight iron bar connecting two oil lamps; a crowd of tourists of many nationalities -- all waiting to enter the Grottoes of Han... Down, down, down, apparently into the very heart of the earth, through damp and chilly air and profound darkness, broken only by the glimmer of the friendly lamps.*

Grotto
de Han
€11.90


The Grottoes of Han in the Ardennes.

> *Still we go on, up and down through grotto after grotto of marvelous beauty; sometimes along the banks of the shadowy river, reflecting in its depths the fairylike beauties of roof and wall, then up high, narrow ridges or down into the depths of inky blackness, until at last we find ourselves in the "Hall of Embarkation." Here a small wooden platform projects over the river, and near it are a number of large boats capable of carrying all our party. The boats push off, all lights are extinguished, and the sensation of total darkness in such conditions is more weird than pleasant. We are told that the water is of unknown depth, and it takes some confidence to repress thoughts of collisions and perils by water of various kinds.*

The suspense -- well, having read Poe regarding subsurface waters, maybe it's not quite that -- is broken by a spot of light.

> *The boats move on in solemn procession, and soon a tiny spark of light appears, and grows gradually larger and brighter. By degrees the light pervades dimly roof, walls, and transparent water, and then, all in a moment, a flood of glorious sunshine gleams through the lofty portal which we are approaching. Behind us fringes and bosses of stalactites are tinged with the warm glow and stand out in bold relief from the darkness; before us the banks are green with grassy slopes and waving trees; below us the river dances along in the sunlight as full of joy at escaping from prison, and we too share its happiness as we float back into our every-day world from the gloomy glories of the Grottoes of Han.*

A bit later,

> *Next we enter the gloomy magnificence of the "Hall of the Dome," where the roof towers up two hundred feet into the darkness. As we ascend the steep path we turn and see below the gleam of water. This is the subterranean river Lesse, the architect of these gloomy grottoes, which until some forty years ago had heard no voice save that of the water hammering and chiseling the rocks at its own sweet will.*

The "hammering and chiseling" is incorrect, as limestone dissolution is molecule-by-molecule, but we'll allow it in prose.

For an update, we have Once Upon a Time in Durbuy, Belgium (2002) by Linda Kaye.

> *We exited the cave by boat, floating on an underground river. As we approached the opening and daylight began to filter in, we were warned to protect our ears from the loud cannon shot*

about to be heard. It is an old tradition used to scare off the evil spirits that might be lurking inside the cave and is still practiced today.

Belgium's Grottes de Neptune, a.k.a.,Grottes de l'Adugeoir, Grottes de Petigny, was explored by Martel (Chapter 49).

A limestone cave swallows the River Eau Noire [Black Water]. The visit continues into the two upper galleries and culminates in a 20 minute boat ride along a channel 10 meters below the river. A number of waterfalls which form the backdrop, but if that's not enough, there's the music of Vangélis and stroboscopic effects.

At 300 meters long, 20 meters wide and 10 meters deep, Switzerland's Saint-Léonard is the largest underground waterbody in Europe. The level was higher until 1946 when a 5.6 Richter-scale earthquake opened additional fissures. Access was closed from 2000 to 2003 while the site safety was improved by 5000 bolts driven into the ceiling.

European Record

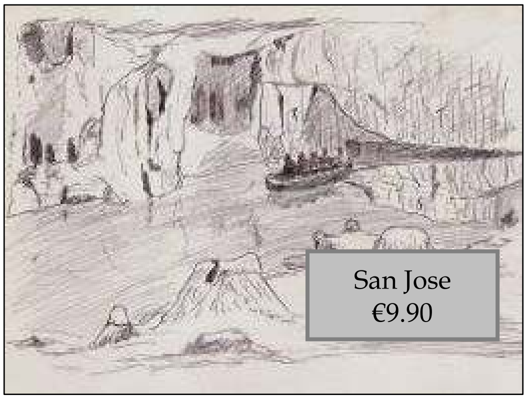
Largest Underground Lake
0.6 hectares

Saint-Léonard
10.00 CHF

San José Cave, la Vall d'Uixó, Spain, is the longest navigable underground river in Europe. The sketch (as photography is not allowed) is by John Burke.

European Record

Longest Navigable Underground River
2.3 km



San Jose
€9.90

A brief aside --

Our attentio to records -- the world's greatest this, the nation's biggest that -- is in keeping with the fact that as a category, underground waters tend to rank high in what we consider worth ranking. In the Almanac and Political Register for 1893, George E. Plumbe proudly notes 13 geographic features in which America is supreme.

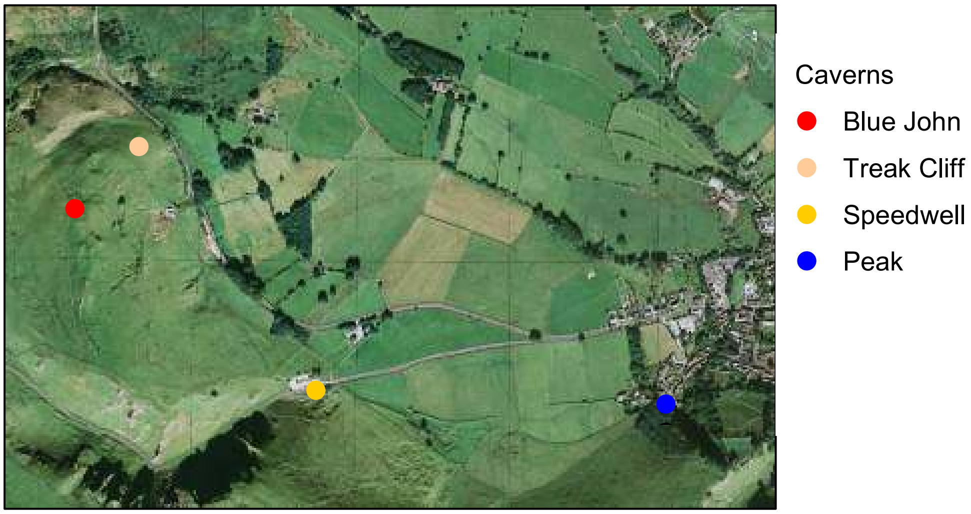
The Greatest Waterfalls	Niagara Falls
The Greatest Cave	Mammoth Cave
The Greatest River	The Mississippi
The Largest Valley	The Valley of the Mississippi
The Greatest City Park	In Philadelphia
The Greatest Grain Port	Chicago
The Largest Lake	Lake Superior
The Longest Railroad	The Pacific Railroad
The Greatest Natural Bridge	Natural Bridge, Virginia
The Greatest Mass of Solid Iron	Iron Mountain, Missouri
The Best Specimen of Grecian Architecture	Girard College for Orphans, Philadelphia
The Largest Aqueduct	Croton Aqueduct, New York
The Largest Deposits of Anthracite Coal	In Pennsylvania

Five of the American triumphs (and perhaps another couple indirectly) relate to underground waters. If underground rivers weren't important, we'd not brag about them, correct?

As is said in Latin, "Q.E.D," "quod erat demonstrandum," "and thus it is proven."

The British Isles

Great Britain has some 20 commercial show caves, of which Derbyshire contains four.



As cavers have traversed the connection between Speedwell and Peak Caverns, we'll discuss just those two.

Speedwell Cavern's accessibility is increased by a horizontal passageway driven by 18th-century lead miners to the karst cavern within. The lower part of the passage forms a canal and the floor of the cavern is permanently flooded.

Undated

c. 1920

1955

Today

The visitor boards a boat for an 800-meters ride. The craft was at one time was propelled by a guide lying on his back, "walking" along the roof. Today, however, the boat is powered by electrically.

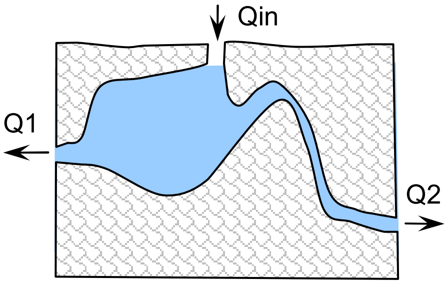
Speedwell
Cavern
£8.75

A roaring becomes progressively louder as the boat approaches the downstream landing. After a short walk, the visitor emerges in a welter of cold spray at the Bottomless Pit, a flooded vertical shaft now choked by spoil from the canal excavation. The original depth is estimated to have been around 150 meters. One can inspect a waterfall descending some 20 meters. The tour takes approximately 45 minutes.

Speedwell's unique hydraulic features, however, are accessible only to the experienced spelunker.

When the Whirlpool Rising (shown to the right) siphons -- and by this we mean a true siphon, not an inverted one -- the period is typically around 10 minutes and water backs and falls by 2 or 3 meters.

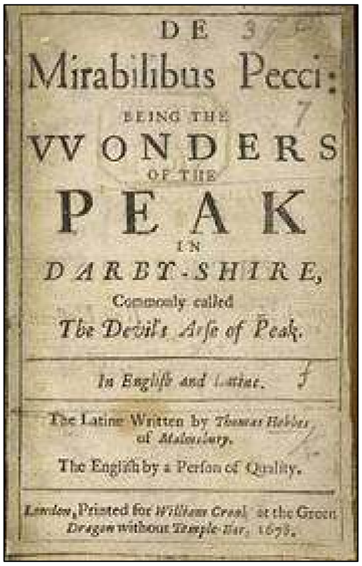
Yet more intriguing is the abrupt switching of major flow between opposing Speedwell conduits during a major flood. While there's yet no proof as to cause, such alternations mimic what might be expected from a cavern having two outlets, one a siphon; the other an orifice. See Chapter 44, Siphons.



Peak Cavern was known as the Devil's Arse because of the allegedly flatulent-sounding noises emanating from within. The name was changed to Peak Cavern in 1880 to not to offend Queen Victoria when she graced a concert in the cave. More recently, the cavern has been promoted by its more improper name.

The cave mouth, 20 meters wide by 30 meters high, the largest cave entrance in Britain -- and some would say, the nation's largest arse -- sits in a limestone cliff 70 meters beneath the ruins of Peveril Castle, built in 1070-80 by the son of William the Conqueror.

Peak Cavern has long been a place of local curiosity, as reflected by De Mirabilibus Pecci (1636) William Cavendish



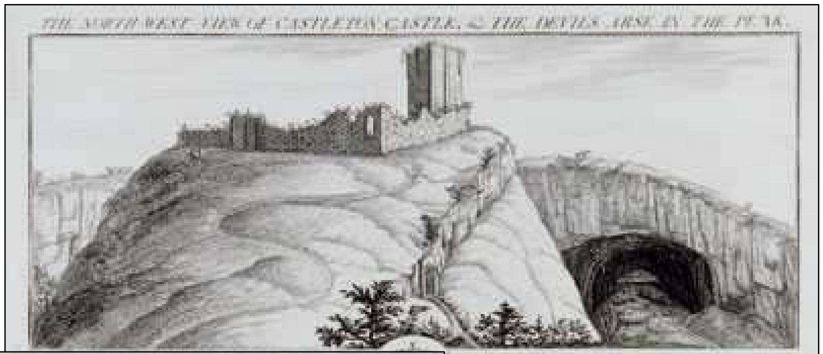
DE
Mirabilibus Pecci:
BEING THE
VVONDERS
OF THE
PEAK
IN
DARBY-SHIRE,
Commonly called
The Devil's Arſe of Peak.

In Engliſh and Latine.

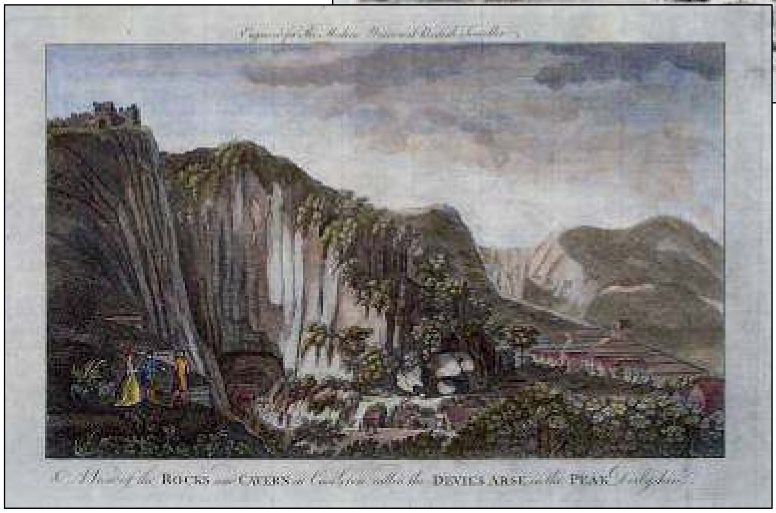
The Latine Written by *Thomas Hobbes*
of Malmsbury.
The Engliſh by a Perſon of Quality.

London, Printed for *William Crook* at the Green
Dragon without *Temple-Bar*, 1678.

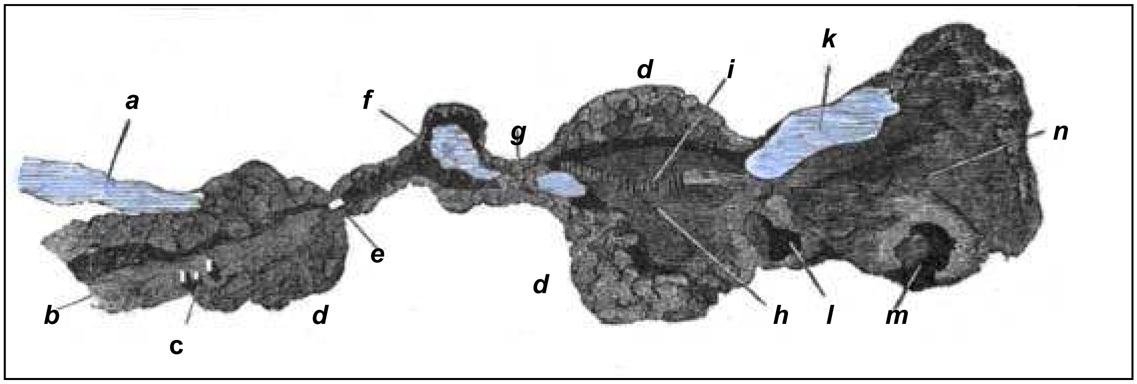
Undated


THE NORTH WEST VIEW OF CASTLETON CASTLE, & THE DEVILS ARSE IN THE PEAK.

1776


Engraved for the Modern Universal British Traveller
A View of the ROCKS and CAVERN at Castleton called the DEVILS ARSE in the PEAK Derbyshire.

Plan of Peak Cavern, 1834


a
b
c
d
f
e
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d
d
i
k
n
h
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m

a. Streams which loses itself among the rocks
b. Entrance to the cavern
c. Cottages
d. Broken rocks fallen from roof and sides
e. Door leading from outer to second chamber
f. Boat in first water, which conveys one person under arch ***g***
h. Grand Cavern
i. Steps cut into sand to descend to second water ***j***
k. Entrance to passage leading to Chancel ***m***
n. Third cavern

Peak Cavern contains about 9000 meters of open conduit. Unlike the neighboring caves, Peak Cavern remains almost exclusively natural, the only altered section being a bypass of tunnel ***f***, until then, only negotiable by lying horizontally on a boat

Peak Cavern
£8.25

Tourist access is by foot along a waterway via a series of bridges. In Roger Rain's House, one passes through spray falling from the roof. The cave is closed when heavy rains raise the water level.

For divers, a 3-meter sump descends to the first squeeze, an L-shaped slot which carries on to a chamber 12 meters below where the floor slopes to a second squeeze and at last an area where one can turn around.

Some of the world's most dramatic cave photography comes from Peak Cavern

Streamflow flow resurges at two locations below the mouth of Peak Cavern. Russett Well (shown on the right) discharges roughly 0.1 cubic meters/second from 16-kilometers of westward karst, drawing from Blue John Cavern and flowing through Speedwell Cavern. Travel time is only 4 days.

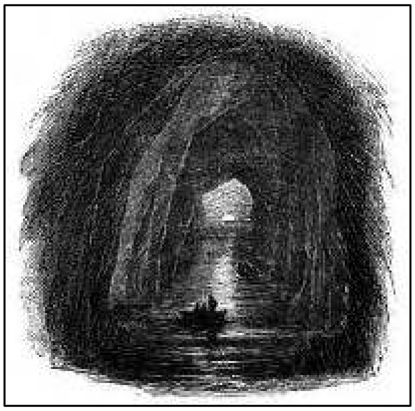
Peak Cavern Rising, the other spring, is intermittent, drawing locally except during floods when Speedwell overflows into Peak Cavern.

The ensuing stream, locally known as the River Styx (see Chapter 55), flows into Peaks Hole Water and on to Castleton.

Castleton's show caves many not be the region's grandest caverns. Titan Shaft, discovered nearby in 1999 via a connection from Speedwell, dwarfs Peak Cavern in height.

In Ten Thousand Wonderful Things (1860), author Edmund Fillingham King honors Ireland's Portcoon Sea Cave with a 153-words sentence.

> *A cave which well deserves a place among our collection of Wonders... is called Port Coon Cave, and is in the line of rocks near the Giants' Causeway. It may be visited either by sea or by land.*



> *Boats may row into it to the distance of a hundred yards or more, but the swell is sometimes dangerous; and although the land entrance to the cave is slippery, and a fair proportion of climbing is necessary to achieve the object, still the magnificence of the excavation, its length, and the formation of the interior, would repay greater exertion; the stones of which the roof and sides are composed, and which are of a rounded form, and embedded, as it were, in a basaltic paste, are formed of concentric spheres resembling the coats of an onion; the innermost recess has been compared to the side aisle of a Gothic cathedral; the walls are most painfully slimy to the touch; the discharge of a loaded gun reverberates amid the rolling of the billows, so as to thunder a most awful effect; and the notes of a bugle, we are told, produced delicious echoes.*

In Wookey Cave, Somerset, the bones of such tropical and Ice Age animals as rhinoceros, bear, mammoth and lion were found along with flint tools. Archaeologists believe the cave was alternatively occupied by hyenas and man from 35,000 to 25,000 BC. There are no fish but divers have seen frogs, eels and freshwater shrimp.

Wookey
£15.50

After resurging the waters from the River Axe, used as power for the oldest operational paper mill in Britain, c. 1610. A corn grinding mill operated there as early as 1086.

In the Mendip Hills near Somerset, Britain's largest underground river, the Cheddar Yeo, flows from below Gough's Cave into Cheddar Gorge, said in the 12th century to be one of the natural wonders of the world. And, yes, the Cheddar region is the home of cheddar cheese.

The rowboat is a bit misleading as a show cave advertisement, however, as it's not available for tourists.

Gough's Cave
£14.80

Gough's Cave is a wonder of nature, of course, but it took decades of blasting and excavation to make it suitable for tourism. From Wells Journal, January 28, 1892,

> *Mr. Gough, the intrepid and persistent cave hunter and explorer, added one more to his list, after two years' toil and expense. The new cave is of colossal size, and contains much beauty, more especially one chamber (form 200 to 300 feet high... Mr. Gough opened up two beautiful rock-work chambers in his search for the underground river... He is still proceeding, and says*

> *he has about 20 yards further to go before he reaches the river. Mr. Gough has been highly successful in his excavations, having found a large quantity of bones and teeth of extinct animals, besides a lot of flint knives and bone instruments, oh which he sets a great value.*

The cave's most notable prize "Cheddar Man, a 9,000-year-old skeleton, and descendent, Flint Jack, are shown below.

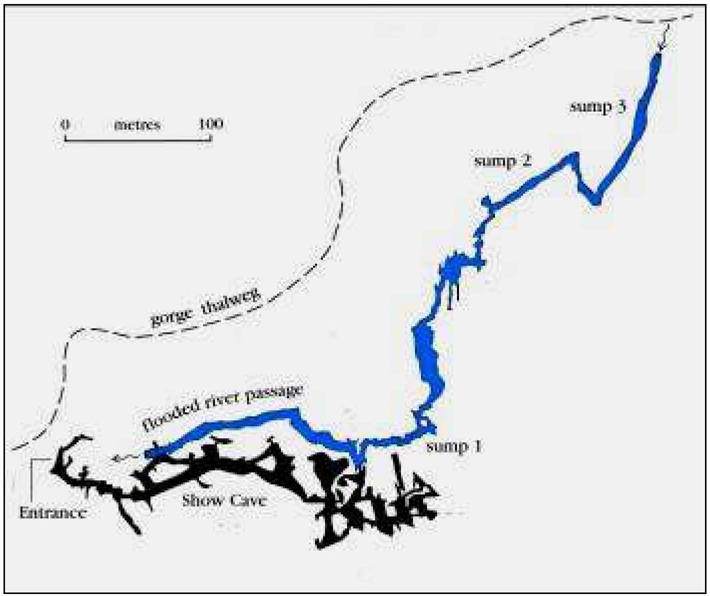
Cheddar Man

12
Keystone View Company
Meadville, Pa., New York, N.Y., Portland, Oregon, London, Eng., Sydney, Aus.

1906 Stereopticon view of Flint Jack

The first 820 meters of Gough's Cave are open to the public, but the greater part of the cavern is river passage, accessible only by diving.

Sump	Length of dive (m)	Depth (m)
1a	150	18
1b	140	?
2	150 with airbells	27
3	370	55



We'll return to the Mendip caves in Chapter 64, Cave Diving.

And before we leave the underground rivers of the British Isles, we must tip our hats to an account that Edgar Allan Poe could have penned. From Thomas West's A Guide to the Lakes, in Cumberland, Westmorland, and Lancashire (1821)

> *The first curiosity we were conducted to was Hurtlepot, about eighty yards above the chapel. It is a round, deep hole, between thirty and forty yards diameter, surrounded with rocks almost on all sides, between thirty and forty feet perpendicular above a deep black water in a subterranean cavity at its bottom. All round the top of this horrid place are trees, which grow secure from the axe; their branches almost meet in the centre, and spread a gloom over a chasm dreadful enough of itself without being heightened with any additional appendages. It was indeed one of the most dismal prospects we had yet been presented with; almost every sense was affected in such an uncommon manner, as to excite ideas of a nature truly horribly sublime. When ever we threw in a pebble, or spoke a word, our ears were assailed with a dismal hollow sound, our nostrils were affected with an uncommon complication of strong smells, from the ramps and other weeds that grew plentifully about its sides, and the rank*

> *vapors that exhaled from the black abyss beneath. The descent of Eneas into the infernal regions came again fresh into my imagination, and the following passage out of Virgil obtruded itself on my memory,*
>
> *Deep was the cave, and downwards as it went*
> *From the wide mouth, a rocky, rough descent:*
> *And here the' access a gloomy grove defends:*
> *And there the unnavigable lake extends,*
> *O'er whose unhappy waters, void of light,*
> *No bird presumes to steer his airy flight:*
> *From hence the Grecian bards their legends make,*
> *And give the name Avernus to the lake.*
> *Iliad, Virgil translated by Dryden.*
>
> *After viewing for some time, with horror and astonishment, its dreadful aspect from the top, we were emboldened to descend, by a steep and slippery passage, to the margin of this Avernian lake. What its depth is, we could not learn; but from the length of time the sinking stones we threw in continued to send up bubbles from the black abyss, we concluded it to be very profound. How far it extended under the huge pendant rocks, we could get no information of, a subterranean embarkation having never yet been fitted out for discoveries... Alas! how fatal would be the consequence, if any adventurer should attempt to wade across the abyss on this shadow of a foundation!*

Middle East and Asia

The 1836 rediscovery of the underground River Jeita in Lebanon is attributed to American missionary Rev. William Thomson, who, venturing 50 meters into the cave, fired his gun. The resulting echoes convinced him that it was a cavern of importance.

Another missionary, Rev. Daniel Bliss, penetrated 1,060 meters in 1873, finally stopped by "Hell's Rapids." The underground system is now known to approach 9 kilometers of length, of which 600 meters are accessible by boat.

The Jeita system is now known to approach 9 kilometers, of which 620 meters are accessible by boat.

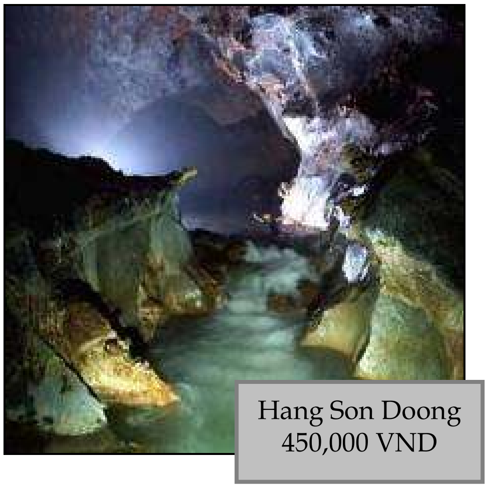
Jeita
L£18.00

Western Iran's Ali Sadr Cave is 11.5 kilometers long, 1.4 of which can be boated by tourists. The cave's discovery during the reign of Darius I (521-485 BC) can be verified by an inscription at the mouth. Knowledge of the cavern was lost, however, and only rediscovered in 1978. Today's visiitors number 400,000 per annum. Plastic boat trains are towed by pedal craft.

Ali Sadr
IR 15,000

Just off the Ho Chi Minh Trail in Vietnam's Phong Nha-Ke Bang National Park, Hang Son Doong Cave extends some 20 kilometers into the karst uplands. At kilometer 1.5, the channel drops steeply to the tidally-influenced lower reach and here -- an exception to most caves where water pools more than it flows --there are rapids.

SƠ ĐỒ HANG ĐỘNG PHONG NHA
Phong Nha water cave's map



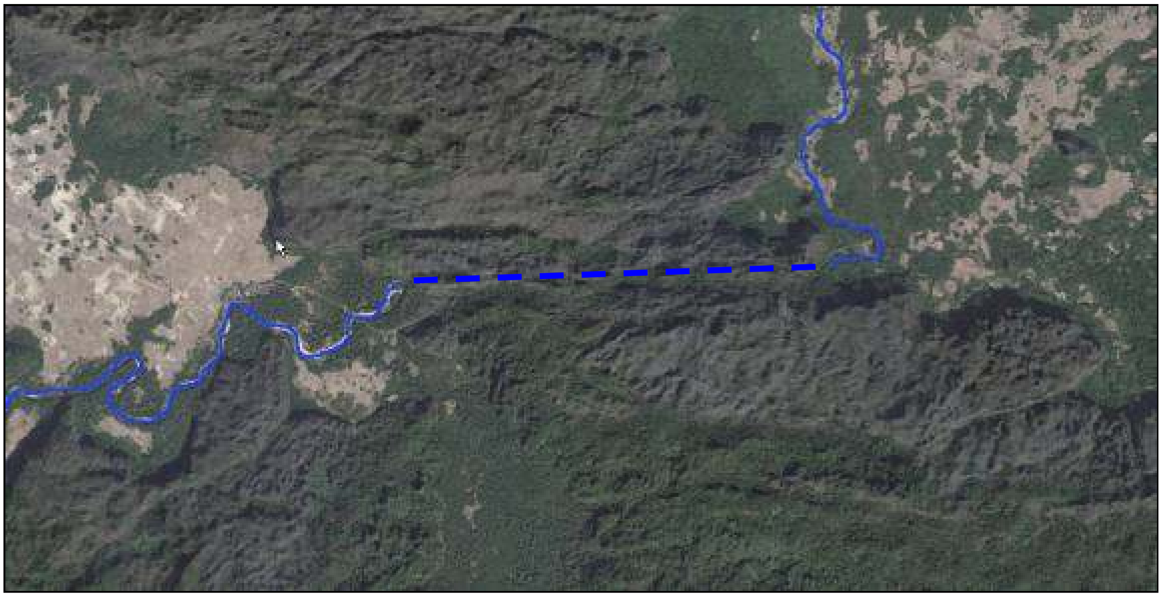
Hang Son Doong
450,000 VND

Konglor
$10.00

Underground rivers navigable from inlet to outlet are rare, but the Konglor cave in Laos connects two valleys separated by a mountain range by a 7.5-kilometer subterranean reach of Hin Boun River. Locals travel the route between cross-mountain Konglor and Natan villages, but so can tourists.

Hin Boun River Downstream

Hin Boun River Upstream



Hin Boun River Subterranean Route

Passages width varies between 20 and 100 meters, with an average between 40 and 50. Height varies from10 to 90 meters, with an average between 40 and 60.

Not much smaller, at 6.7 kilometers, is the nearby trans-mountain Xe Bang Fai underground river where flood discharge can exceed 500 cubic meters/second due to its 1300 square-kilometer watershed. Flows are low during the dry season and passage involves long portages.

The world's longest navigable underground river, Vietnam's Son Trach, is boatable for 11.3 kilometers, but not yet to the public. We include it in the tourism section, however, because the trouists will surely arrive.

World Record
Longest Navigable
Underground River
11.3 km

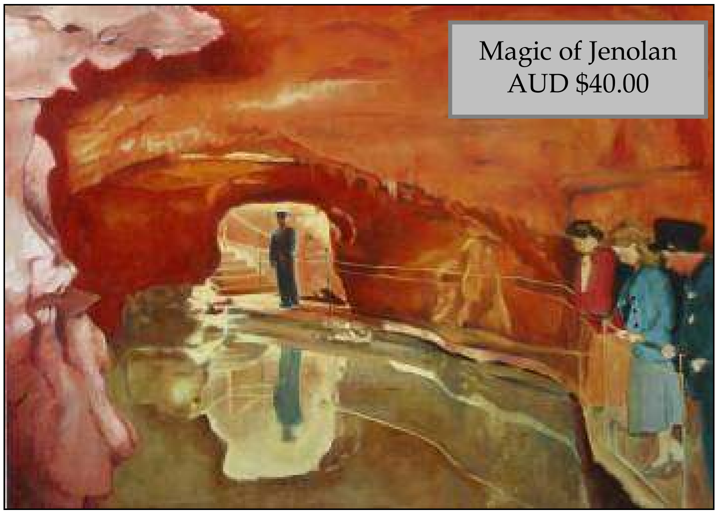
We'll visit the Philippines' Puerto Princesa (a.k.a. St. Paul's) in Chapter 54, Three Tales of Two St. Pauls.

And we'll visit the full color spectrum of Chinese show caves in Chapter 53, Chinese Electricians.

Australia

Jenolan Caves, New South Wales, has its own River Styx, somewhat more true to its nominal inspiration, it that it is underground.

Pool of Reflections, River Styx, Jenolan Caves, 1926



"River Styx," Anna Kristensen, 2006

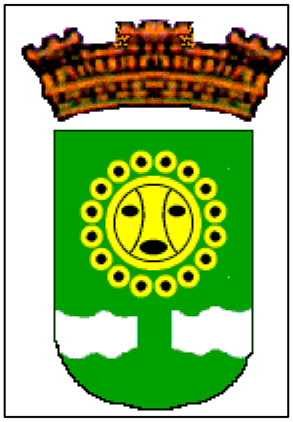
This River Styx, "mostly appearing as large pools of blue water," according to the advertisement -- which is to say that it's not actually a river -- is illuminated from multiple directions to show its color. Until 1923, people crossed the Pool of Reflections on an eight-person flat bottomed boat.

We'll add a pair of 1920s photos for Jenolan Caves, not for what the reveal in particulars, but to show how influenced they were by the Mammoth Cave photography which we viewed in the preceding chapter.

The Americas

The world's third largest underground river flows through Puerto Rico's Camuy Cavern, but there are no boats for hire. In the world's only municipal coat of arms depeicting an underground river, the interrupted stripe symbolizes the river underground for part of its journey.

Camuy
$10.00



We visited the Yucatan Peninsula in Chapter 40, Sinkholes, but didn't mention that one can enjoy it while sipping on a margarita. Xcaret, an "eco-archeological theme park," is a Mexican Disneyland, but one less artificial. In lifejacket and snorkeling gear, one can float for 20-minutes through a 1.5-meter underground channel where natural skylights illuminate marine fossils, stalagmites and stalactites and waterfalls spill over limestone walls. The gear's included in the price of admission.

Xcaret
$79.00

Cancun's Xplor Adventure Park provides a higher-energy alternative to Xcaret, but after Xplor's zip lines, there are both floating and swimming underground circuits on which to relax. Like Xcaret, the formations are real, not Disney.

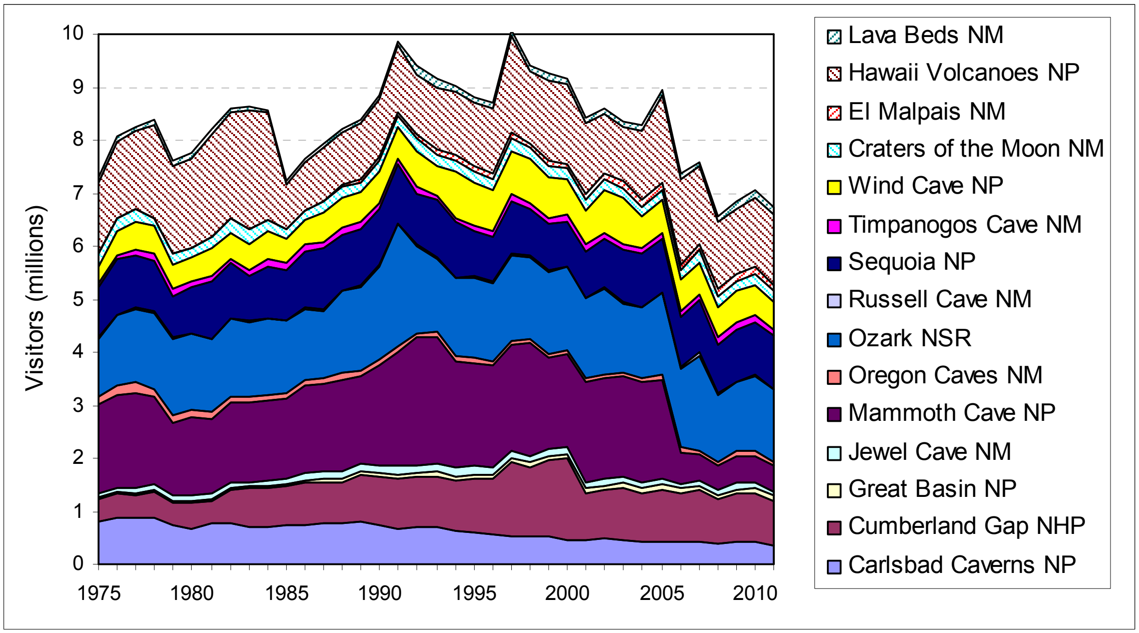
Xplor
$100.00

The greatest number of tourists in the Americas consists, however, are those residents of the United States without a passport. For them, we'll move to the next chapter.

CHAPTER 52
THE AMERICAN TOURIST TRADE

As National Parks, Carlsbad Caverns (Chapter 26) and Mammoth Cave (Chapter 50) are America's best-known subterranean attractions, but the USA has many more such sites. In this chapter we'll mention a few more that feature water.

Eleven units of the National Park Service feature karst caves, and another four, lava tubes. Visitor counts are graphed below, the volcanic parks on the top. The decline in large part is due to management policies to minimize environmental degradation.



About 30 state parks likewise feature caverns.

All 130 commercial caves in the United States are illuminated, have improved access and seem to have gift shops. Vacationers with proper shoes and flashlights can visit at least several hundred less-advertised caverns, some on public land, some on private.

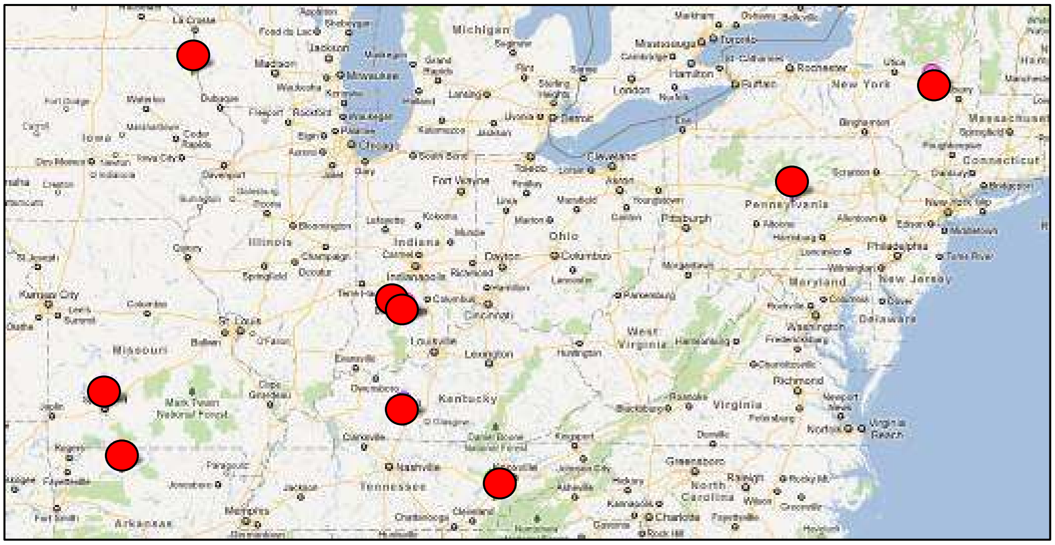
Of these subterranean possibilities for the American tourist, how many offer boat rides?

Not many. There once were more, but by our count, just nine cave boat rides are available to today's paying public, with perhaps an additional few more-local, unpublicized operations.

And why are there so few subterranean boat rides?

Waterbodies are often too far within the cave.
The water is often too shallow to float a boat.
The cave may lack room for boating infrastructure.
Environmental concerns restrain our intrusion.

To boat all nine, we'll need a map and $116.65 for admissions.


Michigan
Iowa
Illinois
Indiana
Ohio
Pennsylvania
New York
Massachusetts
Connecticut
New Jersey
Maryland
Delaware
West Virginia
Virginia
Missouri
Kentucky
Tennessee
North Carolina
Arkansas

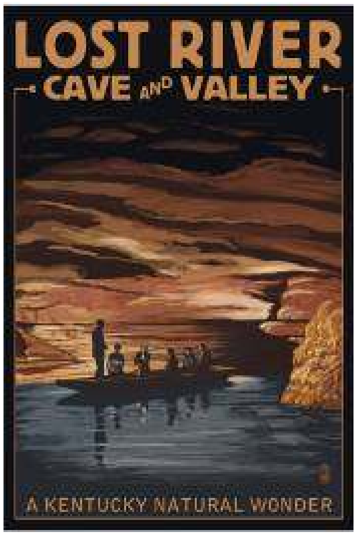
Boat Rides in Show Caves

◆ 1. Lost River, Kentucky -- keep in mind from Chapter 20 that there are many American Lost Rivers -- links Mammoth Cave with the neighboring Lost River Cave through several kilometers of intermittently flooded tunnel.

Lost River Cave housed an undershot mill in the late 18th century. According to local folklore, Jesse James and his gang hid in the cave after robbing the Russellville bank in 1868. A nightclub was operated in the cavern in the 1930s.

In 1993 the cave was opened to tourists and boat tours began in 1999 using boats previously used at Mammoth.

LOST RIVER
CAVE & VALLEY
— Kentucky —


LOST RIVER
CAVE AND VALLEY
A KENTUCKY NATURAL WONDER

Lost River
$15.00

Flood conditions

World Non-Record

Deepest and Shortest Underground River

Ripley's Believe It or Not's claim that Lost River is "the shortest and deepest river in the world" is based on the hydraulically-connected Frenchman Knob Pit, a 133-meter vertical shaft. Mexico's Zacatón cenote (Chapter 40) is 329 meters in depth, but it's not a river.

The tour guide's story within Jane Olmsted's "Lost River," R-KV-R-Y Quarterly (Fall 2006) is of the "dumped-there, found-here" tracing genre we encountered in Chapter 46, Finding the Underground Rivers.

> *The path to the cave entrance led them past a blue hole, Ripley's shortest river, running only 400 feet to the cave entrance. Once believed to be over 400 feet deep, the pool was actually only ten feet deep, linked with the underground river, where a current once pulled in a wagon, a team of horses, a soldier.*
>
> *The guide's voice got low and he looked around, as if he didn't want anyone else to hear. "In a similar incident three soldiers went swimming, one didn't come back, and his two friends, one by one, dove in to see what they could grab hold of. They were never seen again."*
>
> *Forty round eyes met his.*
>
> *"Is that how come they call it the Lost River, 'cause of people getting lost?"*
>
> *The guide turned a page in his mental notes. "Late in the 18th century, some people found sawdust that was dumped into the water here in a pond about three miles away. That's when they realized there had to be an underground river connecting the ponds all along."*
>
> *Getting them into the life jackets took almost twenty minutes of checking, wandering, taking off, putting back on, and finally loading into the boat.*
>
> *Almost immediately, they had to duck their heads as the boat floated beneath a slab of lowered ceiling. Derek could see a series of cracks, inches deep, cut through the surface. They had the fresh look of something about to give. Lucy's elbow gouged into his thigh as she leaned forward. "Tell me when it's over," she said and buried her head in her hands. The ceiling lowered silently, but personally, toward him, and he pressed his face between his knees and told himself the distant grinding wasn't real. As he tilted his head to see how much longer before they cleared the ceiling, Lucy's puffy braid brush against his mouth. A clutch of panic rose in his throat. He pushed her until she lifted her elbow and her head dipped away. He gulped as a rush of air met his lungs. Then the boat slid out from under the slab and they entered a large cavern, the ceiling a reassuring sixty feet above. Lights set up along the walls showed different formations and tiny streams of water that fed the underground river. They all sat up, a collective sigh shimmering across the water to the cave walls and back.*

◆ 2. Lost Sea, Tennessee was not discovered until 1905.

Present this coupon and receive $1 off each adult ticket purchased and 50¢ off each children's ticket purchased. Good for regular tour only. Expires Dec. 31, 2011 Cannot be combined with any other offer or discount. No cash value. BRG

$1 OFF ADULT
50¢ OFF CHILDREN
BRG BRG
THE LOST SEA ADVENTURE!
OPEN YEAR ROUND!
BRG (423) 337-6616 • www.thelostsea.com

.

The visible portion of America's largest underground lake is 250 by 80 meters, but its full extent remains unknown.

Lost Sea Cave might be a world record holder as well, as the area matches that of the self-proclaimed world record holder, Dragon's Breath Cave in Namibia.

American Record
Largest Underground Lake
2 hectares

Glass-bottomed boats powered by electric motors carry visitors onto the lake,

Lost Sea
$17.95

The Lost Sea

The postcard shows what can only be toy boats to make the setting look larger.

Lost Sea is stocked with Rainbow trout. Fishing, however, is not permitted

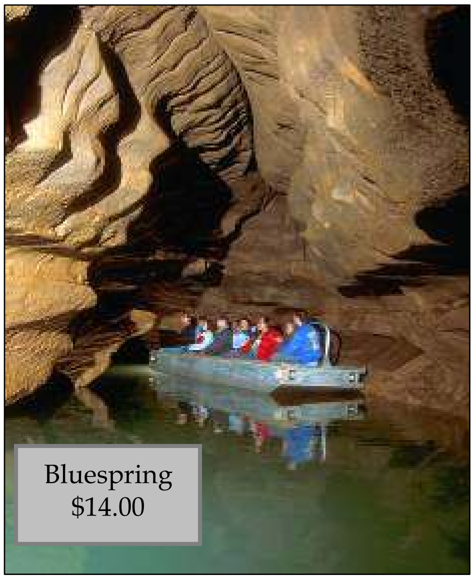
Lost Sea Cave once had a dance floor, a cockfight ring and a moonshine operation, but today it's just another Registered National Landmark with a glass-bottomed boat ride.

◆ 3. Bluespring Caverns, Indiana drain nearly 40 square kilometers of sinkhole plain. Some 50 streams combine in the main cavern river to create America's longest navigable underground river, of which the tourist sees just a fraction.

The cave was accessible by a natural spring portal in the 1800s, but a 1913 dam on the White River blocked that entrance. A natural collapse in 1940 provided today's entrance.

The hour-long electric-powered "Myst'ry River Voyage" is by flat-bottomed boats seating 17. The waterway is famous for an abundance of troglobitic blindfish and crayfish.

American Record
Longest Underground River
30 kilometers



Bluespring
$14.00

◆ 4. Howe Caverns, New York is the Empire State's second most visited natural attraction, after Niagara Falls. The caverns formed where Coeymans limestone overlies more-soluble Manlius limestone. As the latter is dissolved away, an almost perfectly-flat ceiling results.

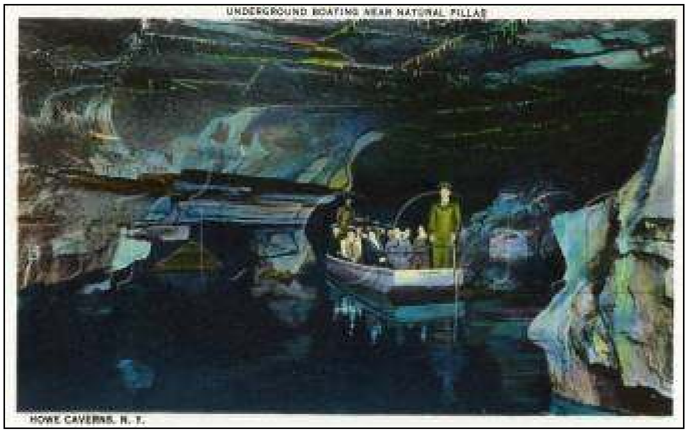
Following is William H. Knoepfel's account of boating Howe Caverns from An Account of Knoepfel's Schoharie Cave, Schoharie County, New York (1853)

> *A boat was procured wherewith to navigate the waters of this lower world... The little craft was lowered by a rope and carried to the edge of the lake, where, not without some show of ceremony, it was launched -- the first launch ever made since the birth of Time into those waters... They entered upon the lake through an arched passage of the rock so low as not to admit of their standing erect in the boat; they took a southerly direction and presently found themselves in water about thirty feet in depth, and so pure and crystalline that the smallest object was distinctly visible, by torchlight, on the smooth sand at the bottom.*
>
> *Another opening in the rock attracted the attention of the party. Upon examining this aperture, which was only twenty inches in height, the passage beyond appeared to expand and the water exhibited a broad, unruffled surface. In the true spirit of adventure it was resolved to explore this passage. A boat was accordingly constructed, corresponding in size with that of the aperture, which was only large enough to admit a single individual in a recumbent position. Having thus passed through the opening, each being shoved or drawn forward by his companions, they found that the rock again ascended in a dome-like shape, and that the lake, expanding as before, stretched onward for about a quarter of a mile before it was hidden from view by a projecting point of rock.*
>
> *The sullen roar of an invisible waterfall resounding through the yawning fissures, added to the mystery and solemnity of the scene; it might have been the haunt of Macbeth's witches, or some sorcerer's cavern, deep down in the bowels of the earth where earthquakes have their beginning.*

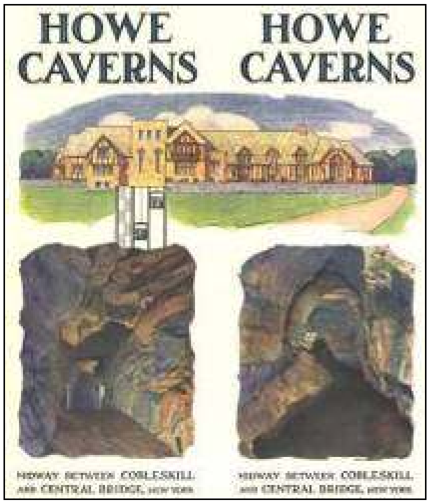
Alas, "it might have been the haunt of Macbeth's witches," but as lamented in Chapter 16, underground-river references to Shakespeare are naught.

Howe Caverns was opened for torch-lit tours in 1843 at 50 cents for an 8-hour descent. Thanks to today's elevator, visitors can now see the same in 90 minutes. The walking trip is 1.6

kilometers; the boat ride, 400 meters. The 20-passenger craft, assembled within the cave, weighs 2.5 tons.


UNDERGROUND BOATING NEAR NATURAL PILLAR
HOWE CAVERNS, N. Y.

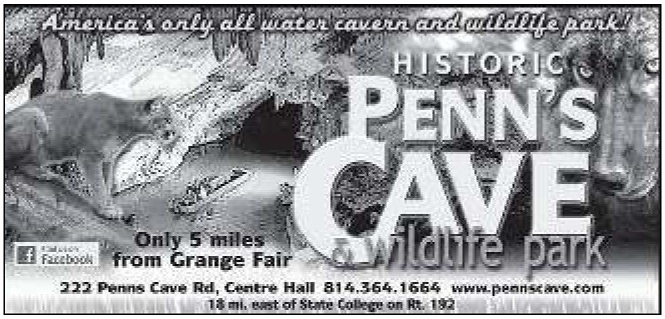
Howe
$23.00


HOWE CAVERNS
HOWE CAVERNS
MIDWAY BETWEEN COBLESKILL AND CENTRAL BRIDGE, NEW YORK
MIDWAY BETWEEN COBLESKILL AND CENTRAL BRIDGE, NEW YORK

RTE. 20 WEST TO I-90 WEST EXIT 25A
HOWE CAVERNS
OPEN ALL YEAR !!

More than 500 weddings have taken place at the Bridal Altar. The wedding fee does not include admission for the guests.

◆ 5. Penn's Cave, Pennsylvania's contemporary advertisement evokes nostalgia, at least until we're invited to "Friend us on Facebook."



America's only all water cavern and wildlife park!

HISTORIC PENN'S CAVE & wildlife park

Find us on Facebook

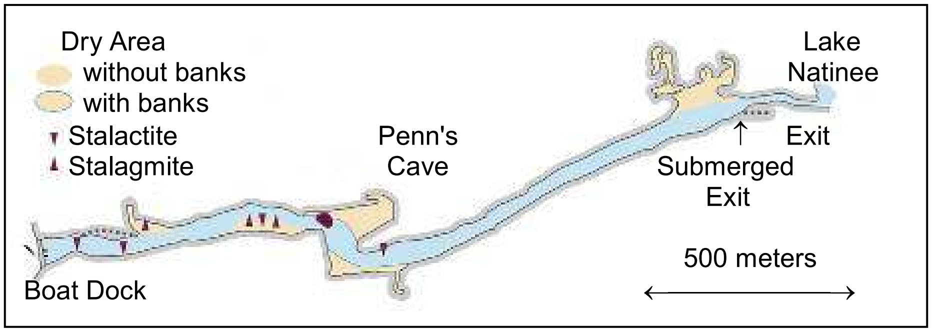
Only 5 miles from Grange Fair

222 Penns Cave Rd, Centre Hall 814.364.1664 www.pennscave.com

18 mi. east of State College on Rt. 192

Penn's Cave
$16.95

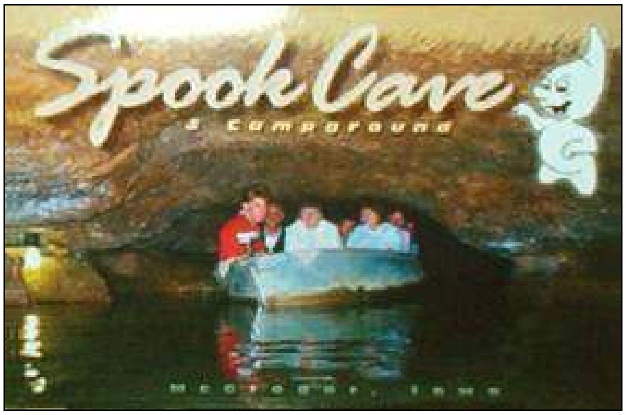
"America's only all-water cavern and wildlife park" does not denote an all-water wildlife park, however; it's a flooded cavern with wildlife topside. For an in-the-water wildlife park, see Chapter 82, Alligators Below.


Dry Area
without banks
with banks
Stalactite
Stalagmite
Penn's Cave
Lake Natinee
Exit
Submerged Exit
500 meters
Boat Dock

◆ 6. Spook Cave, Iowa may be less than a magnificent geologic formation, but as a tourist attraction, Spook does well.

Spook wasn't discovered until 1953, but early settlers spoke of intermittent noises from an opening in the rock. Today, a dam controls the cave's water level and aluminum craft powered by electric motors embark from a landing outside the cave entrance. In the "lover's lane" passageway, "you learn to love your neighbor or you learn to love the wall."

UNDER GROUND RIVER
SPOOK CAVE
McGREGOR IOWA

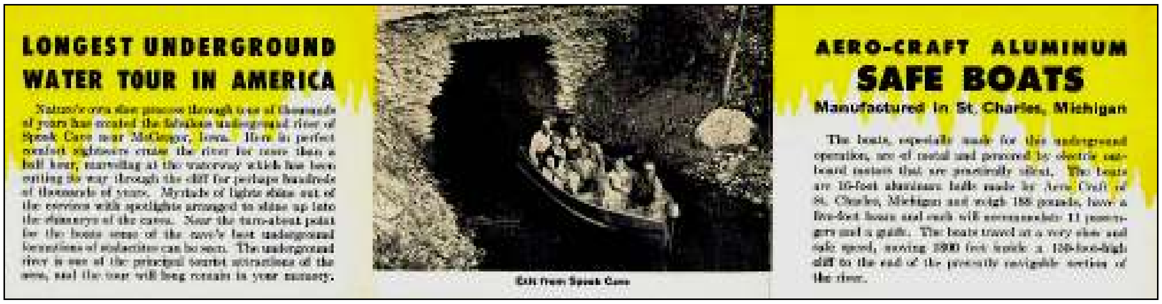

Spook Cave
& Campground
McGregor, Iowa

Penny postcard and recent postcard

Spook Cave
$10.00

Spook Cave
and Campground
McGregor, Iowa

Since construction of the dam, the intermittent noises have not been heard.


LONGEST UNDERGROUND WATER TOUR IN AMERICA

AERO-CRAFT ALUMINUM

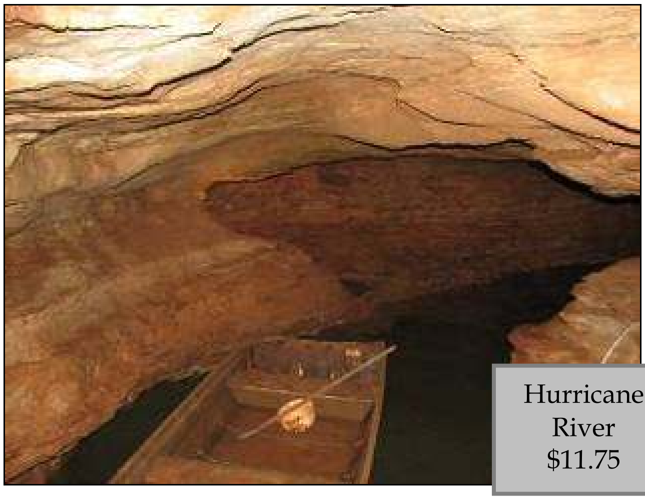
SAFE BOATS

Manufactured in St. Charles, Michigan

Exit from Spook Cave

◆ 7. Hurricane River Cave, Arkansas was opened to the public in 1932, but not until recently did it offer a boat ride, in this case a "wild caving tour" for the more intrepid. The entrance features a 15-meter fake waterfall.

HURRICANE
RIVER
CAVE



Hurricane
River
$11.75

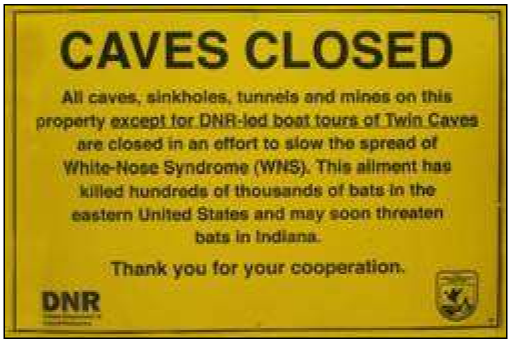
Publically-Owned Boat Rides

Our final two boat rides are publically operated, lack the lighting wizardry and the gift shops of the commercial ventures and don't cost much. They're for the locals.

◆ 8. Twin Cave, Indiana sits on the Mitchell Karst Plain, at an average of 40 sinkholes/square kilometer, one of the highest sinkhole concentrations in America. Cave outflow powered a mill in 1832. The mill is no longer, but reconstruction by the Civilian Conservation Corps created Spring Mill State Park

Twin Cave
$3.00

The 20-minute boat follows the stream 150 meters into the cavern.



CAVES CLOSED

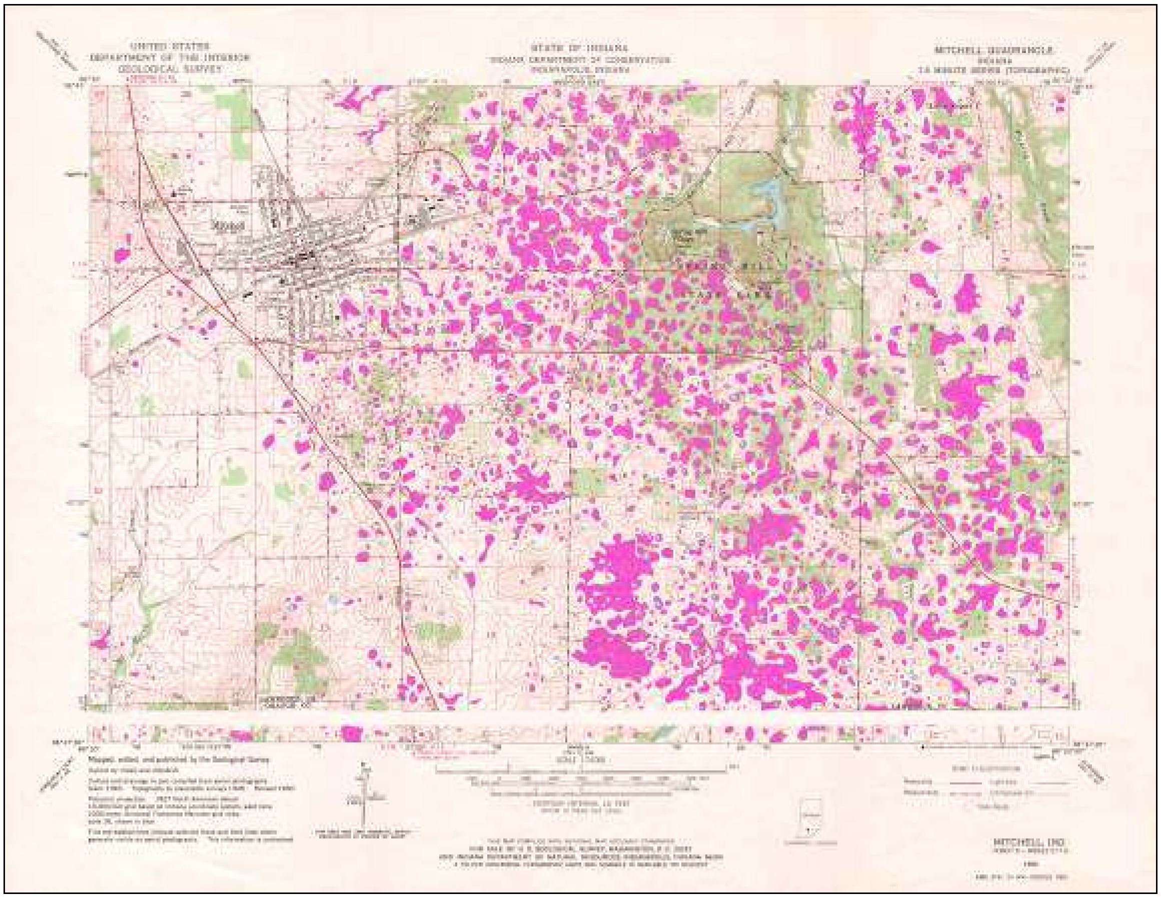
All caves, sinkholes, tunnels and mines on this property except for DNR-led boat tours of Twin Caves are closed in an effort to slow the spread of White-Nose Syndrome (WNS). This ailment has killed hundreds of thousands of bats in the eastern United States and may soon threaten bats in Indiana.

Thank you for your cooperation.

DNR

Bats, blind crayfish, and the endangered Northern blind cave fish inhabit the cave, at times curtailing access.

The top half of the USGS Mitchell. Indiana 1:24000 topographic map exemplifies an extensive sinkhole terrain. We've identified the closed basins with pink. Spring Mill State Park is in the upper-center


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
STATE OF INDIANA
INDIANA DEPARTMENT OF CONSERVATION
INDIANAPOLIS, INDIANA
MITCHELL QUADRANGLE
INDIANA
7.5 MINUTE SERIES (TOPOGRAPHIC)
MITCHELL, IND.

◆ 9. Fishers Cave, in Springfield, Missouri's Sequiota Park offered boat tours in the early 1900s.

Fishers Cave, 1920

Fishers Cave today

In 1920 the site was made into a hatchery for bass, trout, crappie, and perch. The hatchery was removed in 1959 and the boating reinstituted.

Outflow is 0.2 to 0.5 cubic meters/second. Backwater from an exterior dam makes boating possible for 400 meters within. Guided tours by flat bottomed boat are offered on summer Sundays by the Springfield Parks Board.

Sequiota
$5.00

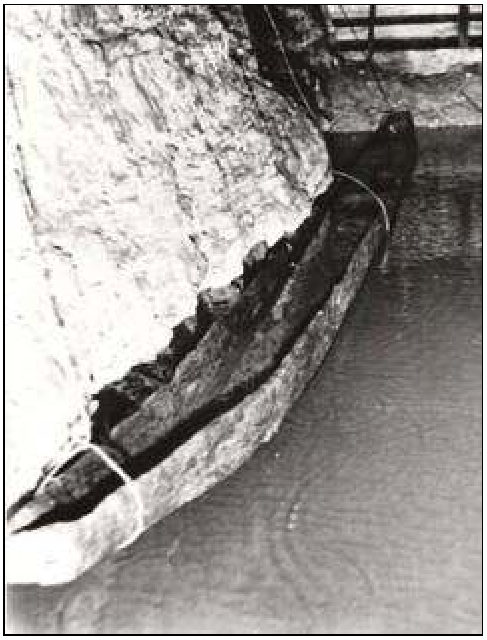
Boat Outings of Bygone Days

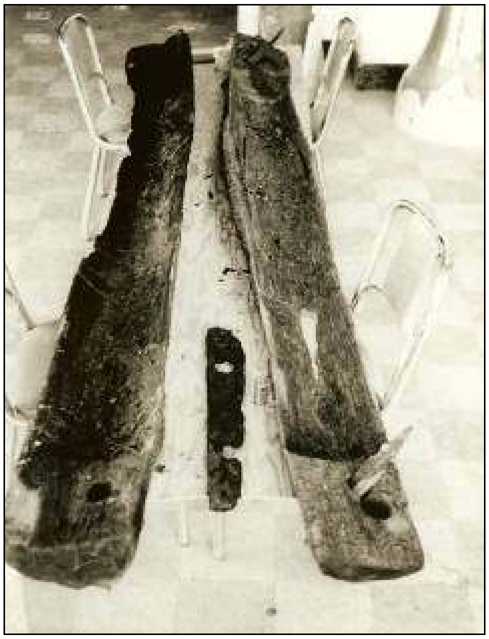
There were more subterranean boating opportunities in days gone by. We'll mention six, but were we to pursue all the caverns in which an entrepreneur has offered a boat ride, the count would be legion.

◆ 1. Keener Cave, Missouri is constantly flooded because it is only 1 meter above nearby Black River. The cave narrows to about 3 meters in width.

Keener's bygone boat rides are indeed bygone. Prehistoric dugouts of an elsewhere-undocumented catamaran type have been retrieved from the pool's depths.

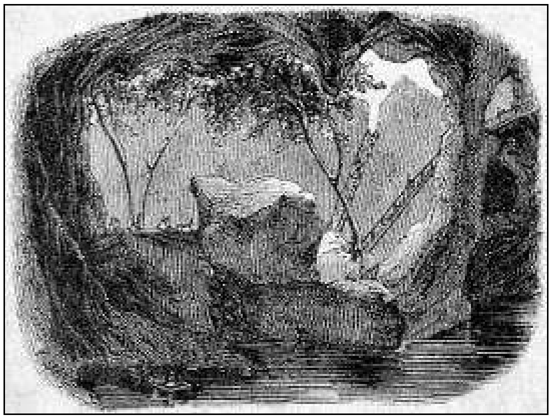
According to "Possible Ritual Use of Canoes in Keener Cave, Wayne County, Missouri," Society for American Archaeology Conference, 2010, St. Louis, by Peter B. Campbell, Susan E. Jansen and J. Craig Williams, the location discounts traditional canoe use, suggesting something ritual.





The modern Keener Cave contains concrete stairs to a dock, but the property's now part of a resort and boating is not allowed.

◆ 2. Bower Cave was a favored respite for excursionists on their way to Yosemite.



From Scenes of Wonder and Curiosity in California (1862) by James M. Hutchings,

> *This is a singular grotto-like formation, about one hundred feet in depth and length, and ninety feet in width, and which is entered by a passage not more than three feet six inches wide, at the northern end of an opening some seventy feet long by thirteen feet wide, nearly covered with running vines and maple trees, that grow out from within the cave. When these are drawn aside, we look into a deep abyss, at the bottom of which is a small sheet of water, made shadowy and mysterious by overhanging rocks and trees. But although there is a singular charm about this spot that amply repays a visit, we must not linger too long, but pay our dollar, and, as the day is probably hot, and the ride a novelty, it will be well for us to take a long siesta here, not fairly starting before three o'clock P.M.*

Indian Head Dollar, 1856-89

The grotto inspired the naturalist James Muir. From his My First Summer in the Sierra (1911),

> *Before noon we passed Bower Cave, a delightful marble palace, not dark and dripping, but filled with sunshine which pours into it through its wide-open mouth facing the south. It has a fine, deep, clear little lake with mossy banks embowered with broad-leaved maples, all underground, wholly unlike anything I have seen in the cave line, even in Kentucky... It's claimed by a Frenchman, who has fenced and locked it, placed a boat on the lakelet and seats on the mossy bank under the maple trees, and charges a dollar admission fee.*

Morgan Dollar,
1878-1921

◆ 3. Alexander Caverns, the third largest spring in Pennsylvania, discharges 0.9 cubic meters/second from a limestone cliff. The dry portion of the cave was discovered in 1926, some 90 meters behind what was then known as Mammoth Spring. An entrance was blasted through 20 meters of limestone in 1930 and the cave was wired. A flight of 115 concrete steps led to a dock from which tourists were boated for a kilometer to daylight at the spring. The tour took more than an hour.

Alexander Caverns

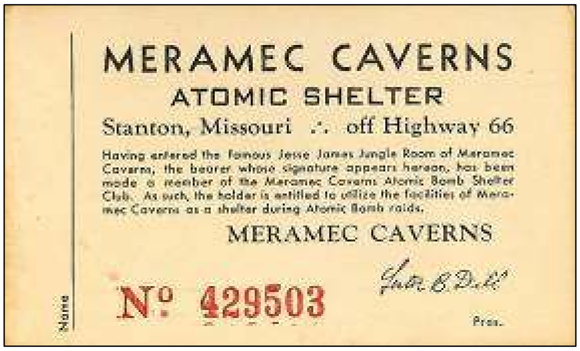
When the lease expired in 1954, the cavern was closed. Today the cave is only open to caving organizations.

◆ 4. Meramec Caverns, Missouri rivals Chinese show caves (Chapter 53) for tacky illumination. Its Big Room has held 2100 people for a meeting of the Oddfellows in 1934, the cave having parking for 300 automobiles. The Fourth Level, reached by stairway, hosted a 224-person mock session of the 1945 Missouri Legislature, surely a political first. The Devil's Bathtub has been since paved with concrete.

The Jesse James Submarine Room, the only chamber containing a stream, has no verified relationship to the outlaw. "Lava River," fed by ceiling seepage, precipitates lime to make a series of rimstone dams, a miniature TVA, but as the stalagmites rising from the water (below left) testify, Crystal Lake and Mirror River are formed by a concrete dam.

Per the swimsuited canoeist on the brochure (above right), we'll count Meramec as a boat ride cave, though to actually do so required lying on the keel and pushing against the ceiling. The pool has since been drained and concrete walks laid.

For similar refuge from atomic bomb attack in New Mexico, see Chapter 26, Subterranean Waterbodies. For Minnesota, see Chapter 54, Three Tales of Two St. Pauls.



MERAMEC CAVERNS

ATOMIC SHELTER

Stanton, Missouri ∴ off Highway 66

Having entered the famous Jesse James Jungle Room of Meramec Caverns, the bearer whose signature appears hereon, has been made a member of the Meramec Caverns Atomic Bomb Shelter Club. As such, the holder is entitled to utilize the facilities of Meramec Caverns as a shelter during Atomic Bomb raids.

MERAMEC CAVERNS

Pres.

Nº 429503

Name

As Meramec lies near Route 66, signage is major.

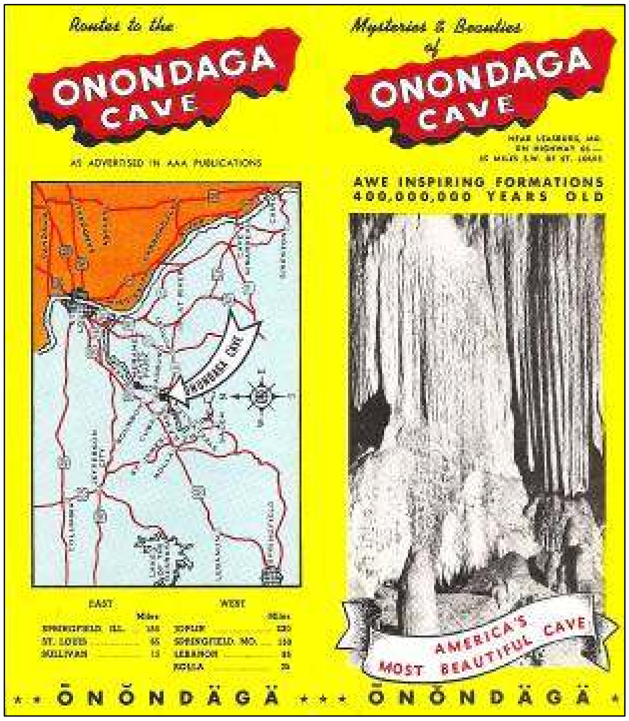
MERAMEC
CAVERNS
115 MILES
STANTON MO.

MERAMEC
CAVERNS
U.S. 66 MO.

◆ 5. Onondaga Cave, Missouri

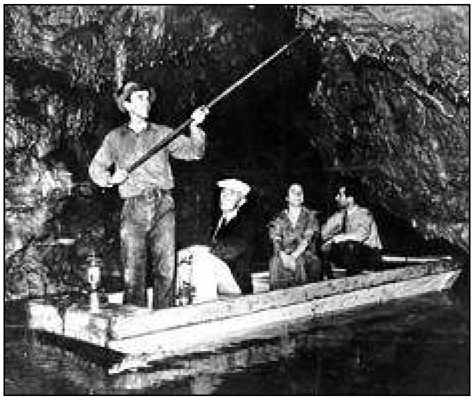
A timeline:

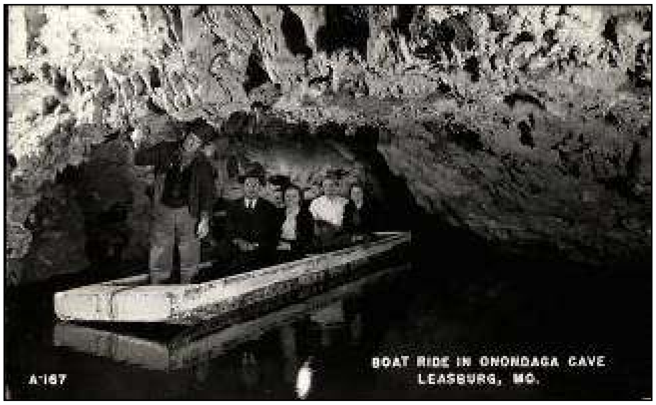
1886	Charles Christopher discovered a cave behind a spring that powered a mill and with two friends in an "Ozark long john river boat," spent the day exploring the "Lost River" beneath the property. Devlopment of the "Mammoth Cave of Missouri" begun.
1897	Tourist access via a 60-meter boat ride through an opening at the spring.
1902	Advertised as a tourist attraction along the railroad during the Louisiana Purchase Exposition.
1938	Walkout dug, the entrance used today.
1953	Boat trips discontinued for insurance reasons.
1982	Designated a National Natural Landmark.


Routes to the
ONONDAGA CAVE
AS ADVERTISED IN AAA PUBLICATIONS
ONONDAGA CAVE
EAST
Miles
SPRINGFIELD, ILL.
ST. LOUIS
SULLIVAN
WEST
Miles
JOPLIN
SPRINGFIELD, MO.
LEBANON
ROLLA
Mysteries & Beauties of
ONONDAGA CAVE
AWE INSPIRING FORMATIONS 400,000,000 YEARS OLD
AMERICA'S MOST BEAUTIFUL CAVE
ŌNŎNDÄGÄ
ŌNŎNDÄGÄ

We're skipping, for now, a real estate episode of that involved a barbed-wire fence and future-President Harry Truman. We'll catch it in Chapter 77, Public Access to Underground Rivers.

Boating within Onondaga

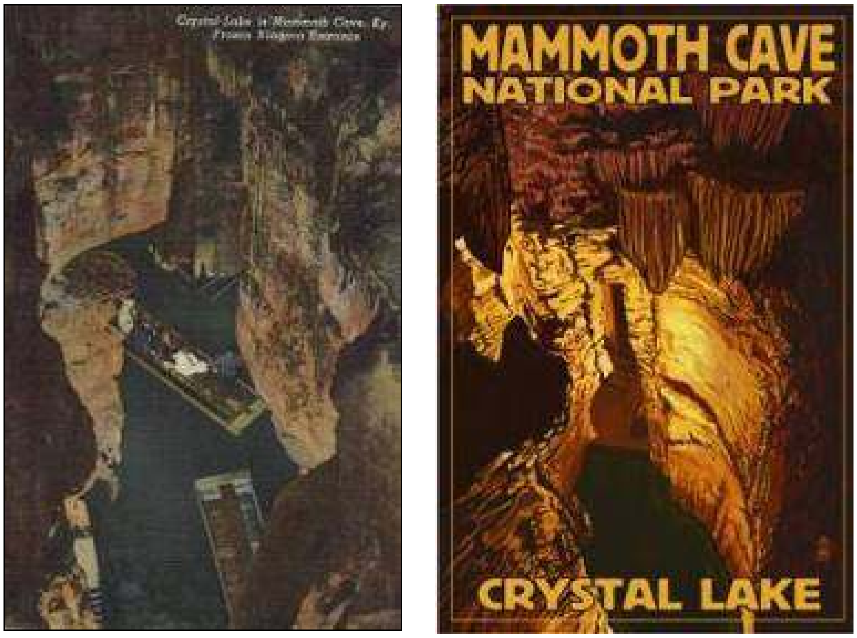



A-167
BOAT RIDE IN ONONDAGA CAVE
LEASBURG, MO.

◆ 6. Kentucky's Crystal Cave, like its neighbor, Lost River Cave, is also connected to Mammoth. Crystal Cave's "The Most Beautiful River Ever Discovered" was on a man-made lake.

1924

Crystal Cave was incorporated into the National Park in 1961 and so ended the boat rides.


Crystal Lake in Mammoth Cave, Ky.
Frozen Niagara Entrance
MAMMOTH CAVE
NATIONAL PARK
CRYSTAL LAKE

Crystal Lake, c. 1915 and Crystal Lake today

Subterranean Water Vistas

We'll limit ourselves to caves in which a tourists peer at dark waters, albeit perhaps just a reflecting pool.

◆ 1. Luray Caverns, Virginia were illuminated by tallow candles until 1881 when arc lights were installed.

Luray
$21.00

THE BEAUTIFUL CAVERNS OF LURAY

"REFLECTIONS IN DREAM LAKE", LURAY CAVERNS, VA.

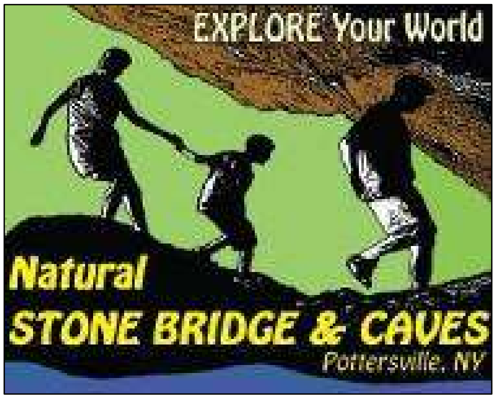
As a navigable underground river, Luray's unexceptional, but it does have a wishing well that's earned $400,000 for charity. The caverns have also been the site of 450 weddings. TV programs featuring Luray Caverns include,

That's Incredible
Huntley-Brinkley Report
Good Morning America
Ripley's Believe It or Not
National Geographic Television
The Simpsons
MTV
Mr. Rogers

Portions of The Other Side of Midnight (1977) were filmed in Luray. As the site lacks bats, much less ones that attack humans, the Special Effects Department produced replicas.

◆ 2. Natural Stone Bridge, New York is typical of multi-generational family-owned tourist attractions, featuring such diversions as Frisbee golf, a Gold Rush Mine, fish feeding and Cavekid Bouldering Wall.

Natural Stone Bridge
$80.00



Natural Stone Bridge's river is described in Morse's Geography (1796),

> *In the county of Montgomery is a small, rapid stream... it runs under a hill, the base of which is 60 or 70 yards in diameter, forming a most curious and beautiful arch in the rock, as white as snow. The fury of the water and the roughness of the bottom, added to the terrific noise within, have hitherto prevented any person from passage through the chasm.*

As reported in A Gazetteer of the State of New York (1824) by Horatio Spafford,

> *A person may follow the stream with ease, 156 feet from the entrance, where it becomes too contracted as to check any farther progress.*

In more recent times, the subterranean passage was opened to allow a "mermaid" to swim some hundred meters from Echo Cave to Artists Gorge. Below are three such mermaids.

Lydia Neubuck, 1945

STONE BRIDGE & CAVES
N.Y.

Connie Kelly, 1966

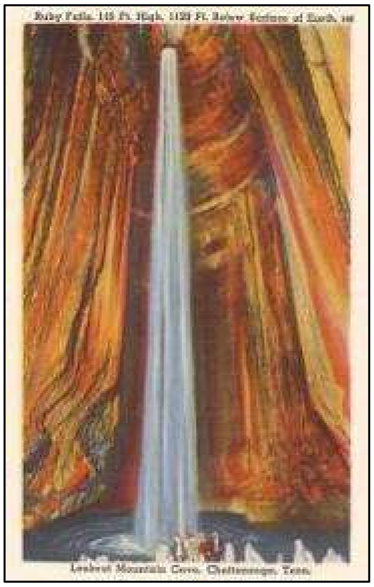
Dee Beckler, 1980s

The mermaids have since retired, but today's visitor can "explore a water filled cave that previously only our 'mermaids' were allowed to venture in."

From the Natural Stone Bridge brochure,

> *The tour starts under the largest marble cave entrance in the east... Next is Noisy Cave to sit in some waterfalls and then go right though the fall to pop out of the river to the surprise of folks on the standard tour. A slide down into Kelly Slide Cave is next, an older part of the cave system with small stalactites and flowstone. The grand finale is a cave float through Echo and Garnet Cave out into the Artists Gorge and Oyster Shell Cave.*

◆ 3. Lookout Mountain Cave, Tennessee boasts the world's tallest underground waterfall, 44-meter Ruby Falls, 340 meters beneath the surface.


Ruby Falls 145 Ft. High, 1120 Ft. Below Surface of Earth.
Lookout Mountain Caves, Chattanooga, Tenn.

World Record
Highest Underground Waterfall
44 m

RUBY FALLS
LOOKOUT MOUNTAIN

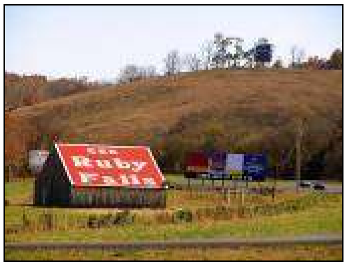
Ruby Falls
$11.50

An early account of the spectacle from "A Wonderful Cave," Ogden Standard Observer, August 4, 1883,

> *Ahead of them was heard the roar of rushing waters and they soon encountered a waterfall, its height being twenty-seven feet.*
>
> *A branch led to the left, and with a short distance they beheld another waterfall, the cliff rising to a sheer height of 150 feet. The water came over with a roar like thunder, the volume being fully twelve inches in diameter. With the meager facilities at hand they could not proceed any*

> *farther in that direction, and returning to the main channel, again advanced... They then stood in an immense chamber, fully 200 feet wide, almost circular in shape; walls of solid stone rose on all sides, and the roof spanned it as a dome. From the center of the dome a stream of water poured, falling in the center of the chamber. The stream was fully twelve inches in diameter, and was icy cold and clear as crystal.*

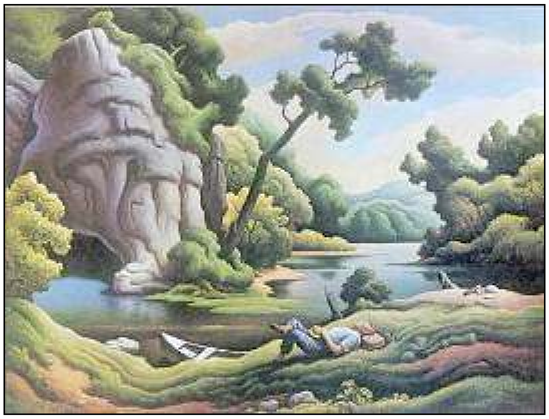
Ruby Falls
ON LOOKOUT MTN.



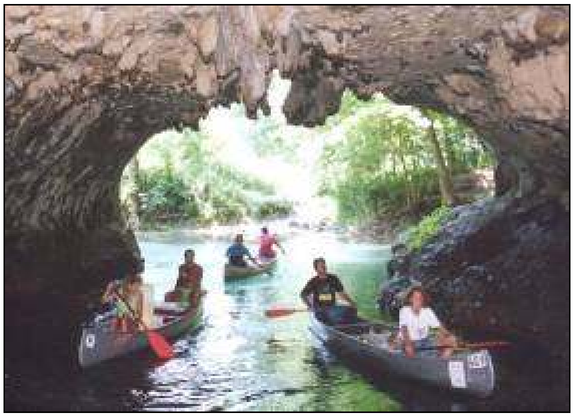
SEE Ruby
Falls

◆ 4. The Ozark National Scenic Riverways in Missouri contains some 300 caves, of which here we'll visit just two, Cave Spring, a subterranean tributary along the bank of the Current River and the tributary's source, Devil's Well, a sinkhole 3 kilometers to the north.

In terms of underground river tourism, we've nearly all the classification options. The cave's privately owned by a foundation, but freely open to the public. Devil's Well is owned by the National Park Service. The cave can only be accessed by canoe, while the sinkhole can only be inspected from a viewing platform. We'll list this with the viewables, rather than the tour boats, as the Ozark National Scenic Riverways a destination of scenery.



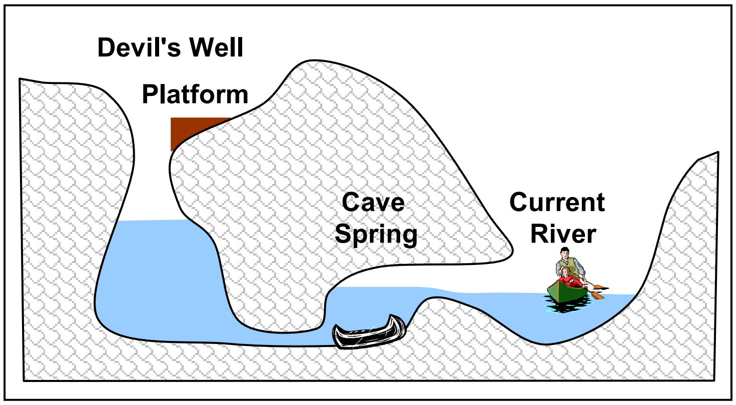
"Cave Spring, Fishing in the Ozarks," 1963, Thomas Hart Benton, a leader of the Regionalist art movement.



Today, canoe-jams are not uncommon at the cave entrance.

Cave Spring upsurges at 0.9 cubic meters/second at the rear of the cave, some 40 meters within.

Parts of a Native American dugout were recovered from the spring depths during underwater mapping in 1964.



Devil's Well contains the largest known underground lake in the state, 120 by 30 meters and 20-odd meters in depth, the latter fluctuating 3 meters with the weather.

Previous owners commercialized Devil's Well in the 1960s with a picnic area, a store and a spiral staircase to a viewing platform 30 meters above the pool. The National Park Service bought the property in 1974. Though there is an electric light, not much of the water is visible.

5.3-meter canoe used in the 1960s survey

View from today's viewing platform

The Cave Spring system has a lengthy history of canoeing.

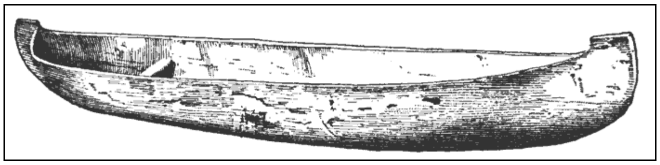
The prehistoric craft in the spring,
The 1960s survey, and
Today's multitude of Current River paddlers.

Dugout canoes have been discovered in several other American caves:

The Kentucky report of "an Indian canoe, drifted there, doubtless, from some other water course and preserved so long by the pure atmosphere of the cave," Chapter 46, Finding the Underground Rivers

The hulls found in Keener Cave, earlier in this chapter

Carver's Cave in Minnesota, which we'll visit in Chapter 54, Three Tales of Two St. Pauls



Spelunkers

For a not-too-strenuous outing, a show cave fits the bill. At the other end of the exertion spectrum are the risky, rarely-penetrated caves. Between the family vacationers and intrepid explorers are those willing to descend on their own into subterranean environments that, while perhaps adrenalin-inducing, have been safely negotiated by many. These are the recreational spelunkers, often organized into clubs or "grottos."

If we inquire locally, we may learn of a few favorite sites.

River Cave, Indiana is frequented by flashlight-equipped cave boaters.

River Cave's initial 70 meters is more than 2 meters deep. Depth averages 1 meter for another 100 meters, beyond which the stream feathers out.

The Caves of Missouri (1956) by J. Harlen Bretz catalogs what was known to cavers -- or perhaps better put, what was revealed by cavers who may have kept a few sites secret -- in the 1950s. Below are condensed references to several of the Show-Me State's lesser-publicized cave-boating possibilities.

An unnamed cave "near Climax Springs" is said to contain a lake upon which rowboat voyages are possible for a "mile in a straight line" without "even approaching the opposite shore." In the opinion of the writer, "effusions of some enraptured reporter."

The writer prepared for half a day of boating in Turner Cave, but could proceed for only 150 meters. Whoever said he got three miles into the cave in a boat was gifted with imagination. The stream flows swiftly and brokenly in places over its rock floor.

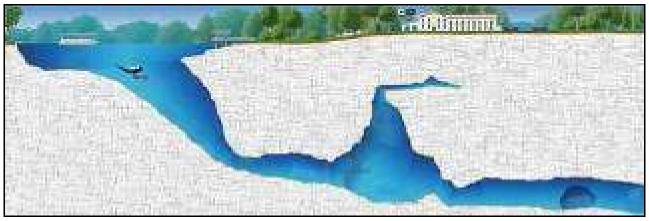
> In the 1890s, cave onyx from Kempton Cave is said to have been was floated from the interior by flat-boat to a landing 60 meters from the entrance, and there loaded on small rail cars.
>
> Cave Spring discharge is between 0.7 and 2.1 cubic meters/second. At low water, a strong current flows out of the cave. In high water, the mouth is completely submerged. Except for a mud-covered rock shelves unreachable except by boat, the cave floor is entirely submerged.
>
> Sinkin Cave can be entered only by boat. A subterranean lake, 60 meters in diameter and 25 meters deep, lies a short distance inside and discharges from the mouth
>
> Welch Spring varies between 2.2 and 8.8 cubic meters/second. When the writer visited, there was no boat available, and no materials for making a raft. A spotlight illuminated a narrow, straight, vertical slot, its ceiling some 5 meters above the water. As no turbulence was evident, the slot must be deep below the water surface. At about 30 meters, there was a turn to the reported subterranean lake.

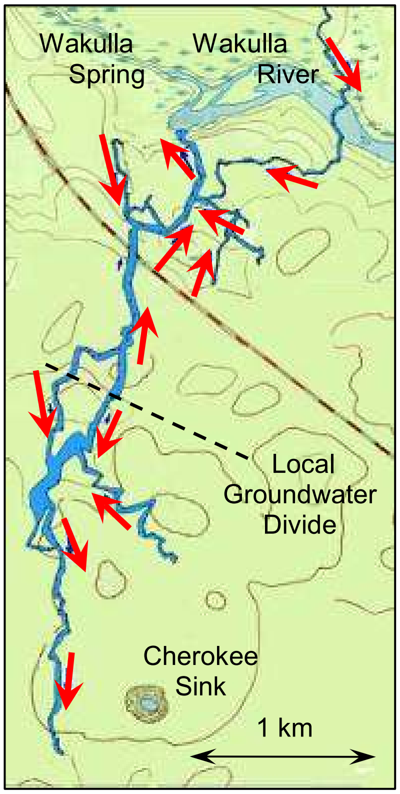
Few of the tens of thousands of accessible caves in the United States, many of which contain enough water to float an inflatable craft, are not "tourist trade" in the business sense, but such caves can play a significant role in local economies by virtue of the dollars spent by spelunkers in pursuit of their passion.

Sinkholes

We'll conclude our tour of vacation destinations with three sinkholes in Florida, the geology of which we covered in Chapter 40. Vacationers do not see the subterranean channels, per se, but enjoy the myriad of diversions surrounding the waters' emergence.

◆ 1. If semi-direct rainfall is excluded, Wakulla Spring's 25 cubic meters/second discharge makes it one of the largest freshwater springs in the world.



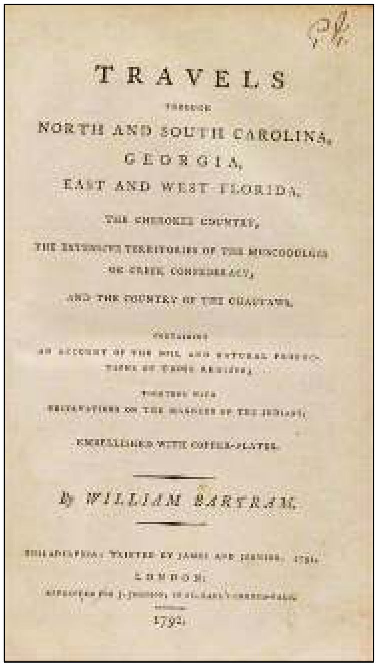


Wakulla issues from a dendritic karst network of conduits, the largest trending south from the spring for 5.5 kilometers, of which 3.2 have been explored. Secondary conduits total 4.3 kilometers. Eleven smaller conduits measuring 1.2 kilometers in combined length connect to the secondary conduits. The conduits do not follow noticeable fractures.

An average velocity of 1 meter/second in the smaller conduits was estimated by calculating the rate at which a resting diver is propelled down-gradient.

Wakulla
$8.00

William Bartram traveled in Florida between 1765 and 1777, publishing in 1791 a large book with a lengthy title, Travels through North and South Carolina, Georgia, East and West Florida, the Cherokee Country, the Extensive Territories of the Muscogulges, or Creek Confederacy, and the Country of the Chactaws, containing an Account of the Soil and Natural Productions of those Regions, together with Observations on the Manners of the Indians.



TRAVELS

NORTH AND SOUTH CAROLINA,
GEORGIA,
EAST AND WEST FLORIDA,
THE CHEROKEE COUNTRY,

By WILLIAM BARTRAM.

LONDON:

1792.

At Wakulla, Bartram saw the mouth of an underground river emerging en route to the Gulf and described the strata of limestone and clay that open for waters emerge as rivers above ground until once again sinking into the sand.

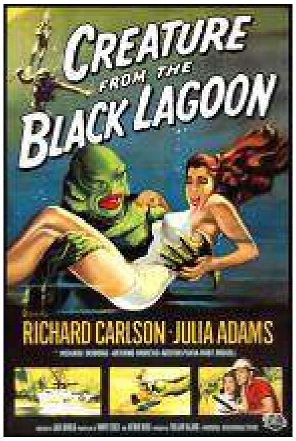
> *These waters…augment and form… subterraneous rivers, which wander in darkness beneath the surface of the earth, by innumerable doublings, windings and secret labyrinths; no doubt in some places forming vast reservoirs and subterranean lakes… and possibly… meeting irresistible obstructions in their course, they suddenly break through these perforated fluted rocks, in high, perpendicular jets…. Thus by means of those subterranean courses…they merge…in those surprising vast fountains.*

A few Wakulla memories

Notes on the 1918 photograph indicate that the couple spotted an ivory-billed woodpecker, today believed to be extinct.

WAKULLA SPRING

1947 De Soto Suburban


CREATURE FROM THE BLACK LAGOON
RICHARD CARLSON · JULIA ADAMS

Filming of "Creature from the Black Lagoon" (1953)

Chapters 62 and 65 catalog the dangers of swimming and falling in, but as we're at Wakulla, here is a pair of cautionary tales-- one old, the other, recent.

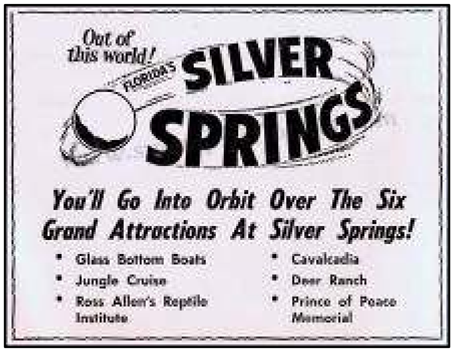
“Buried in an Underground River” in Kirk Munroe's Wakulla, A Story of Adventure in Florida (1886) is fictional, but plausible.

> *He grasped wildly at the bushes; but they were torn from his hands, and he felt himself going down, down, down, and in another instant was plunged deep into water that closed over his head. He came to the surface, stunned and gasping, only to find himself borne rapidly along by a swift current. He did not for a moment realize the full horror of his situation, and with the natural instinct of a swimmer struck out vigorously.*
>
> *He had taken but a few strokes when his hand hit a projecting rock, to which he instinctively clung, arresting his further progress. To his surprise, on letting his body sink, his feet touched*

> *bottom, and he stood in water not much more than waist deep, but which swept against him with almost irresistible force.*
>
> *Then in an instant he comprehended what had happened. He had been flung into a "sink hole," and was now buried in the channel of one of those mysterious underground rivers of which Mr. March had told them a few nights before. That was at home, where he was surrounded by his own loving parents and friends. Should he ever see them again? No; he was buried alive.*

Nobel laureate (for his contribution to quark theory) MIT Prof. Henry Kendall died while diving in Wakulla in 1999. He'd been one of the volunteers mapping 5 kilometers of the cave using propulsion vehicles and re-breathing devices.

◆ 2. Silver Springs, headwater to the St. Johns River, produces some 24 cubic meters/second, not much less than Wakulla. The site's been a tourist draw for more than a century.



Out of this world!

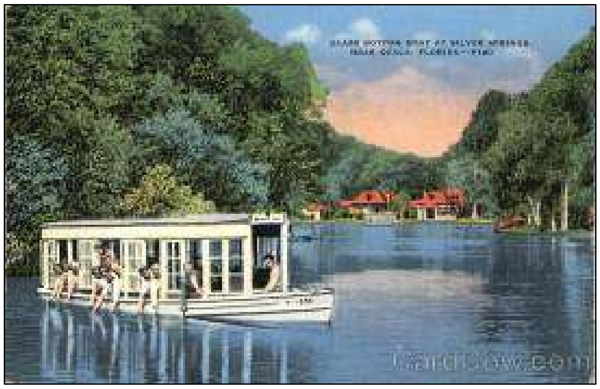
FLORIDA'S SILVER SPRINGS

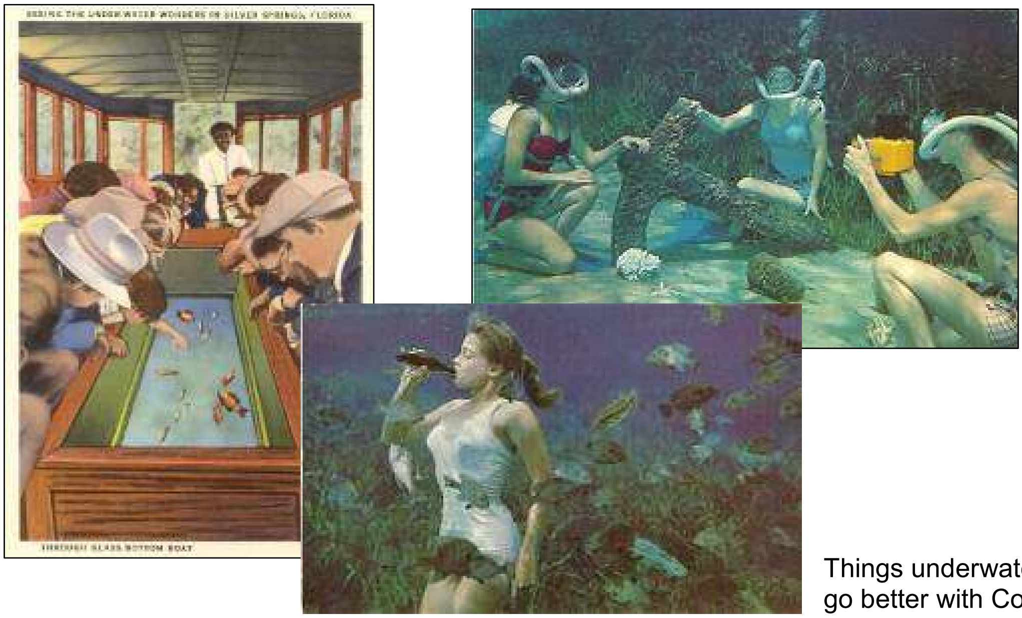
You'll Go Into Orbit Over The Six Grand Attractions At Silver Springs!

- Glass Bottom Boats
- Jungle Cruise
- Ross Allen's Reptile Institute
- Cavalcadia
- Deer Ranch
- Prince of Peace Memorial

Sputnik-inspired advertisement

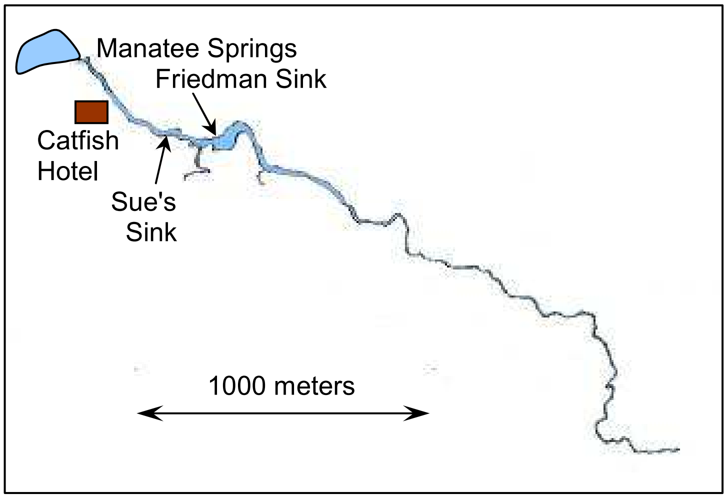
1902




SEEING THE UNDERWATER WONDERS OF SILVER SPRINGS, FLORIDA
THROUGH GLASS BOTTOM BOAT

Things underwater go better with Coke.

◆ 3. Manatee Springs produces somewhat more than 4 cubic meters/second.


Manatee Springs
Friedman Sink
Catfish Hotel
Sue's Sink
1000 meters

Bartram's ovservation,

> *We entered the grand fountain... The ebullition is astonishing, and continual, though the greatest force of fury intermits, regularly... The ebullition... subside*[s] *with the waters at the moment of intermission, gently settling down round about the orifice... At those moments when the waters rush upwards, the surface of the basin immediately over the orifice is greatly swollen or raised a considerable height; and then it is impossible to keep the boat or any other floating vessel over the fountain; but the ebullition quickly subsides; yet, before the surface becomes quite even, the fountain vomits up the waters again, and so on perpetually.*

Manatee no longer flow per Bartram's description and human impact has caused the native submerged vegetation to be replaced by algae.

Manatee Springs
Canoes for rent

1960s

Summary

Our vacation's included

Contemporary subterranean boat rides, mostly commercial establishments, but some public,
Another set of caves that once offered boat rides,
Show cave rivers traversed by foot,
Caves frequented by those a bit more daring, and
Sinkholes where we can paddle above the river emergences.

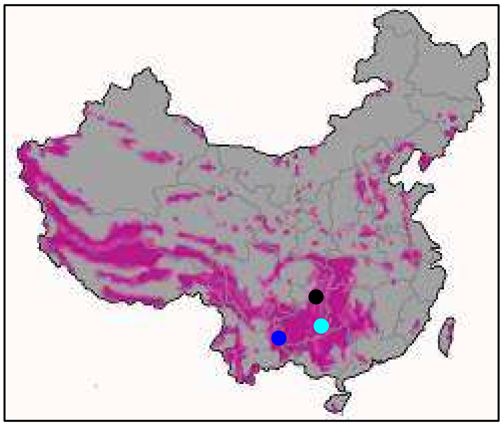
We'll visit more touristic spots throughout our journey, but as with any vacation, it's better to spread things out.

CHAPTER 53
CHINESE ELECTRICIANS

The world's largest karst area, 500,000 to 600,000 square kilometers stretching across southern China, is shown to the right. Centered in Guizhou Province, eastern Yunnan Provence (of which nearly 44 percent of the landscape is karst) and Guangxi Province, major karst extensions reach into Chongqing, Sichuan, Hunan, Hubei and Guangdong and Tibet

UNESCO declared three clusters of southern China karst to be World Heritage Site in 2007:

- ● Chongqing Wulong Karst, which includes Sanqiao Natural Bridges, the Three Natural Bridges, the Furong Jiang karst gorge, caverns surrounding Furong Cave and the Qingkou Houping tiankengs (Chapter 39)
- ● Transitional Guizhou Libo Karst between Guizhou plateau and Guangxi lowland, and
- ● Yunnan Shilin Karst



As half the exposed limestone in the world lies in China, it is likely that half of all the world's caves -- and by extension, underground rivers -- are Chinese. In "Environmental Health Crises in Southwest China," China Environment Forum, November 8, 2006, Prof. Yuan Daoxian reported that southwestern China contains 2,836 such rivers and streams, in total almost equal in length to the 5,464-kilometer Yellow River. More than half of these passageways have been explored.

As anticipated by Dehao Zhu in "China's Karst Tourism Resources and Their Position in the World," Carsologica Sinica, January 1992,

> *Karst caves, subterranean streams and karst springs also are other important valuable kinds of tourism resources. All the karst tourism resources form the firm and favorable basis for the development of Chinese tourism.*

World-wide, there some 650 show caves artificially illuminated with improved walkways and/or mechanical transport. From 1980 to 1995, China opened more than 400 such caves. In 1995 there were 40 million visitors.

European show caves have been electrically illuminated since 1880, but in that regard, Chinese electricians are today leaving the rest of us in comparative darkness. As measured by subterranean formations subjected to kitsch colored spotlights, garish neon panels and blinking bulbs, China leads the world.

We dedicate this chapter to the prodigious Chinese electricians.

Let us take a tour. We'll cite more cave measurements that one cares to hear, but they won't be as mind-numbing as the photos.

Jiuxiao Biyun Dong (Blue Cloud Cave), Anhui Province

At 28,000 square-meters and 24-meters high, Jiuxiao Biyun is known as "Asia's Largest Hall in Hole." The site is noted for its underground lake.

Jiuxiao Biyun
CNY 28

Furong Cave (Lotus Cave), Chongqing National Municipality

Furong, a show cave 2.85 kilometers long with width varying from 30 to 50 meters, serves as a jarring reminder of the interplay between caves and rivers, but in this case, not even a cave river. On January 26, 2003, 29 days after the beginning of filling nearby Jiangkou Reservoir, a 3.5-Richter earthquake caused stalactites to collapse. The water table brought about by the reservoir has since affected drainage of the karst.

Furong
CNY 70

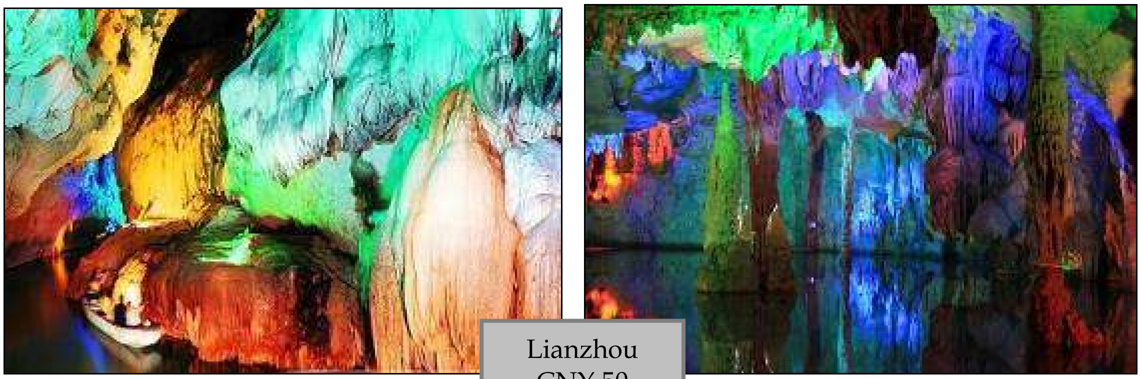
Lingshan Dong (Lingshan Fairyland, Yunquan Cave), Gansu Province

Lingshan lies within in the city limits of Hangzhou. Its 24.5-meter stalagmite, falsely touted as the highest in Asia, is known as Tianzhu Peak. The tour includes a 102-meter long staircase and 480-meter boat ride.

Lingshan
CNY 38

Lianzhou Underground River, Guangdong Province

Lianzhou's three floors total to 1.9 kilometers, the lower encompassing an underground river that zigzaging through three gorges: Longmen, Lotus and Banana, named according to their shapes.



Lianzhou
CNY 50

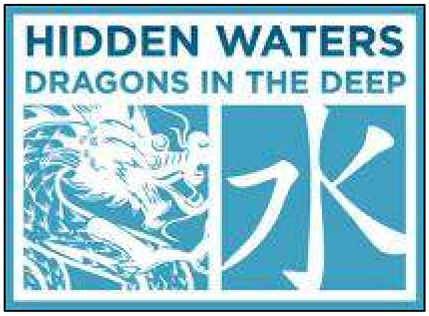
Julong Tan (Assembling Dragon Cave), Guangxi Zhuang Autonomous Region

Julong Tan, popular with domestic tourists, is more than 1 kilometer long, 25 meters at its highest point and 30 meters at its widest. A quarter of the route, the Wudi Pool, is navigable by boat or walkable by plank road.

Julong
CNY 45

This cave is the first of 10 "dragon"-named river caves in our tour, a Chinese mythological association now worldwide, as illustrated by the logo of "Hidden Waters, Dragons in the Deep," a 2010 photography exhibit of Chinese cave waters at the Woodrow Wilson International Center for Scholars.

The script 龙, "lóng," is "dragon."



Lianhua Dong (Lotus Basin Cave), Guangxi Zhuang Autonomous Region

The cave, 481 meters deep, 25 meters wide, and 38 meters high, contains more than 100 lotus-leaf shaped limestone basins, each roughly 30 centimeters deep. The largest is 2.5 meters across and some basins contain smaller basins. The walls ring when struck. As with Chinese show caves, Lianhua is opulently illuminated, at least when the electricians are working.

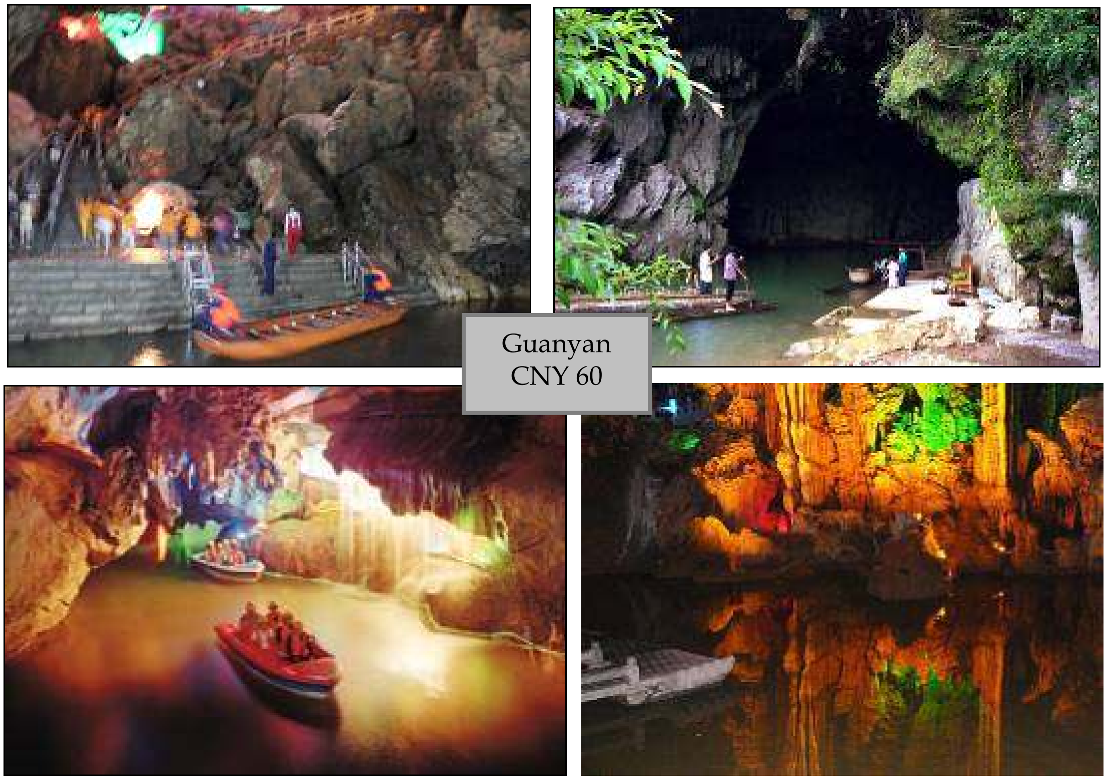
2006, Full wattage

Lianhua
CNY 23

2009, Green lights burned out

Guanyan Dong (Crown Cave), Guangxi Zhuang Autonomous Region

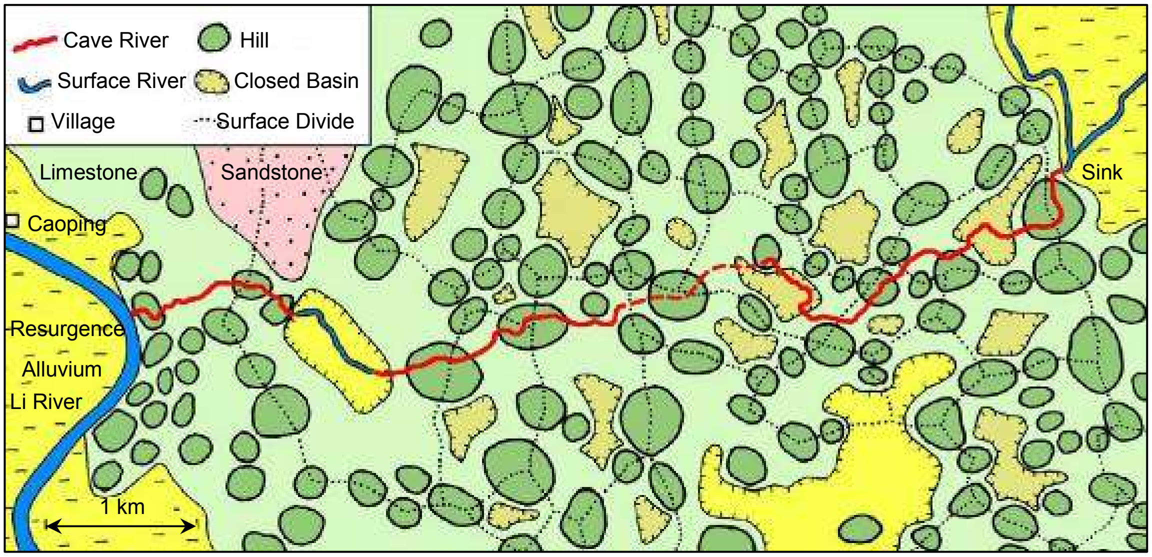
Since 1637, the 12-kilometer cave system on the bank of the Li River has attracted poets, scholars, nobles, and more recently, hydrogeologists. The underground beaches consist of fine and round sand particles themselves said to be natural wonders. The 3-kilometer, 90-minute tour includes a 36-meter elevator to the cave hall, walking, boating and railroading. A waterfall echoes throughout the cavern, but a separate ticket is required to view it.



Guanyan
CNY 60

"Fengcong, Fenglin, Cone Karst and Tower Karst," Cave and Karst Science 35:3, 2008, by Tony Waltham, describes Guanyan's overlying landscape.

The subterranean river's route can be seen below, running right to left.

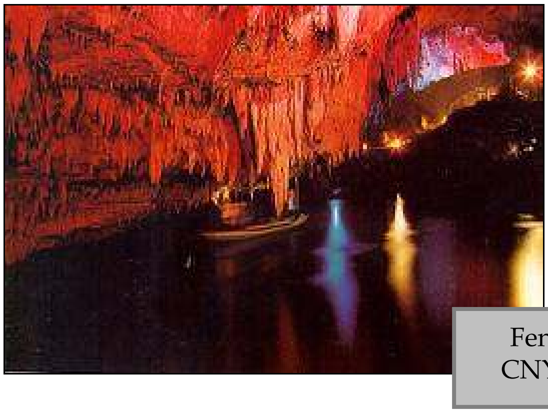

Cave River
Hill
Surface River
Closed Basin
Village
Surface Divide
Limestone
Sandstone
Sink
Caoping
Resurgence
Alluvium
Li River
1 km

Fengyu Yan (Rich Fish Cave), Guangxi Zhuang Autonomous Region

Named after its red cave fish, Fengyu is 5.3 kilometers in total length of which 4.3 are river passages. The main passage is 6 to 10 meters in width and 3 to 10 meters high. The largest chamber is more than 25,500 square meters and 36 meters tall. The boat tour is 3 kilometers.

Fengyu features fast-growing stalagmites several meters high, but only 10 to 20 centimeters in diameter. The multi-colored light are said to make them look like ancient pagodas. For strobe lights, there's the cave's discotheque.

At Fengyu's entrance, discharge is roughly 0.5 cubic meters/second and roughly 30 centimeters deep. At the exit, the values are three times greater.



Fengu
CNY 43

According to Prof. D.C. Ford, former chairman of Cave Association of China,

> *Fengyu Cave is a new bright pearl of Guilin tourism district, and it makes tourism of karst landscape in Guilin perfect and faultless*

Ludiyan Dong (Reed Flute Cave), Guangxi Zhuang Autonomous Region

Named for the reed grass at the cave mouth used to make flutes, Ludiyan was an air raid shelter during World War II. Today it hosts black tie dinners.

Ludiyan
CNY 60

Ludiyan's also offers a turtle show -- large forlorn amphibians stuck on a table with tourists prodding, shouting and sticking money on them.

Zhujin
CNY 60

Zhijin Dong (Hen Hitting Cave), Guangxi Zhuang Autonomous Region

The system's length is 12 kilometers. The height and width of the main passage is between 60 and 100 meters. Other chambers reach a height of 150 and a width of 175 meters.

Longmen
CNY 90

Longmen Dong (Moon Water Cave), Guangxi Zhuang Autonomous Region

After the 90 minute boat ride along 3 kilometers of the half-meter deep river, one can take a mud bath and then shower under the waterfall.

This Longmen Dong is not the like-named UNESCO world heritage site, the Buddhist grottos in Henan..

Longquan
CNY 50

Longquan Dong (Dragon Spring Cave), Guangxi Zhuang Autonomous Region

Longquan's lower level is 1.2-kilometer river passage is floored with clastic sand and gravel.

Laomei Dong (Leye Show Cave), Guangxi Zhuang Autonomous Region

The visitor entrance is above where the river disappears into the hillside. The cave consists of 460 meters of nearly-horizontal passage, 2 to 3 meters wide. The cave's characteristic feature is the lotus-like formations that appear as islands in shallow pools.

Lipu Dong (Silver Cave), Guangxi Zhuang Autonomous Region

Lipu extends fro 2 kilometers beneath 12 hills, from which visitors can boat on to Green Lake

Longgong Dong (Dragon Gate Cave), Guizhou Province

Dragon Palace Scenic Area is a 60-square-kilometer network of more than 90 caves, some wet and some dry. A 34-meter waterfall pours from Tianchi Lake into Longgong to form a 5-kilometer underground river, the longest navigable reach in China. Channel depth is as much as 28 meters and width exceeds 30 meters.

Longgong
CNY 50

Longgong consists of two chambers, the outer having a platform of about 1000 square meters and the inner having a dock where boaters can disembark.

Yinshui Cave, Hubei Province

Yinshui, with its "special nuclear power road passing by the entrance," is 5 kilometers long, averaging 30 meters high and 25 meters wide. Tourists may explore by boat, railcar or by foot.

Tenglong Dong (Soaring Dragon Cave), Hubei Province

Tenglong is one of the world's largest caves, 33.5 kilometers being the distance between sink and spring. The entrance is one of the world's tallest, 74 meters.

Tenglong inflow is by a 10-meter waterfall. A concrete path hugs the cave wall about 20 meters above the flow, the latter deepening as it is narrows.

A concrete bridge crosses the river at the first narrows and exits the cave on the opposite side.

The path then continues along the exterior cliff to a dry entrance, 50 meters wide and 60 meters high.

From here, the cave is toured by electric vehicle on a concrete path at up to 50 kilometers/hour, what we presume to be a world record.

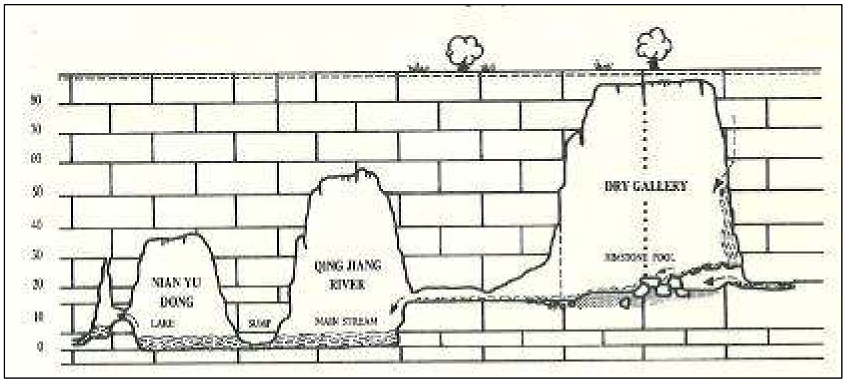
Entrance

Tenglong
CNY 180

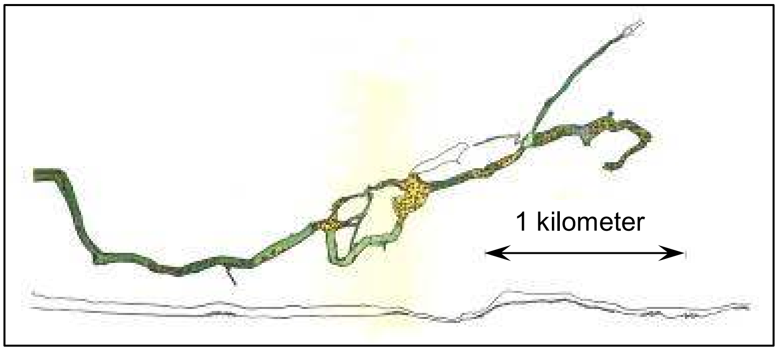
Downstream junction

After 2.2 kilometers, a theatre chamber is reached where artificial fog enhances the laser show. Investors have spent $18 million on the project.

Teng Long Dong, The Longest Cave of China (1988), Report of the First Belgian-Chinese Speleological Expedition, provides some geologic detail.



- 🟩 Stream Action
- 🟩 Phreatic Cave
- 🟨 Breakdown Zone
- ▨ Fallen Rocks
- ▨ Sand
- ▨ Silt or Clay
- ▨ Sand and Silt
- ▨ Rimstone Dams
- ▨ Springs
- ▨ Rock Pendants
- ▨ Fracture
- ▨ Fissure



Morphogenetic Mao

Baima Dong (White Horse Cave), Hubei Province

The large karst cave is 2.1 kilometers long and visited by boat.

Baima
CNY 22

Huanglong Dong (Yellow Dragon Cave), Hunan Province

Huanglong is one of some 40 caves in the Wulingyuan Scenic and Historic Interest Area. Its river is one of some 60 streams that flow underground. The cave contains 11 kilometers of passages in 4 levels, 13 chambers, 96 passages, 3 waterfalls, 2 underground rivers, 3 pools, and 1 underground lake. One of the waterfalls is 50 meters high; the biggest chamber has a floor of 4,000 square meters. The 2-hour guided tour covers 3.2 kilometers, 2.4 by foot, the remainder by boat. There are over one million visitors per year.

Huanglong
CNY 80

Longwang Dong (Dragon King Cave), Hunan Province

The totally length of this cave is about 30 kilometers. With an average height of 50 meter and width of 80 meters, there are 58 halls, 28 stone corridors, 15 pearl waterfalls, 3 underground rivers, 2 lakes and 45 pools.

Longwan
CNY 40

Shanjuan Dong (Cave of Hidden Kindness), Jiangsu Province

This cave system total length is about 5 kilometers, of which the flooded portion is but 120 meters with a depth of about 4 meters. A 120-meter waterfall cascades from middle level to the cave river. The boat tour exits via a narrow, low-ceilinged channel to an opening called "Sudden Light."

Shanjuan
CNY 38

Shennong Gong (Dragon Palace), Jiangxi Province

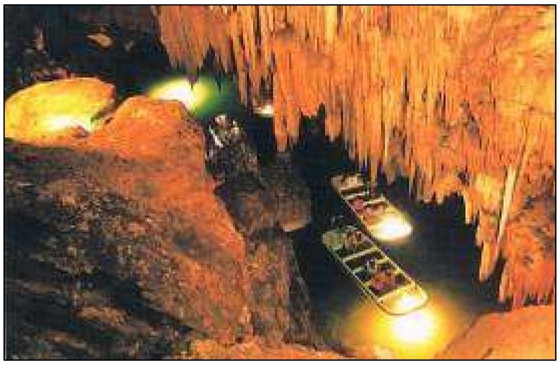
This 2.7-kilometer show cave was opened to the public in 2005.

Shennong
CNY 70

Benxi Dong (Nine-Curve Silver River Cave), Liaoning Province

The cave was opened to the public in 1983 and made Benxi Water Cave National Park 11 years later. Annual visitor count is approximately 1 million. The boat ride lasts 30 minutes.

Benxi
CNY 180



The Benxi system covers a distance of over 5 kilometers; the largest cavern is 6,000 square meters. Behind the 25 meter-wide, 7-meters high entrance portal is a chamber is a 50-meters-long, 20-meter-wide portal with a pier sufficient for 40 boats.

The river, 0.23 cubic meters/second mean discharge, is up to 7 meters deep. The passage is up to 38 meters high and 50 meters in breadth. Coats are provided, as the temperature is 12°C.

Yishui Underground Grand Canyon (Shandong Underground Gorge), Shandong Province

Leased for 60 years to an entrepreneur, the 6-kilometer river cave is developed for more than half its length. To visit to the theme park within the cave, one rides a railway and an inflatable boat for 1 kilometer. The attraction received 670,000 visitors in 2010.

Yishui
CNY 60

For those interested in tax law:

Underground Grand Canyon's owner, Shandong Longkong Travel Development Co. Ltd., is controlled by a shell company in Hong Kong,

Which is owned by holding company in the British Virgin Islands,

Which is owned by Long Fortune Valley Tourism Intl Ltd.,

Which in 2010 was merged by Dallas-based Halter Financial Group into BTHC XV, a Delaware holding company listed on the U.S. stock exchange,

Which was created in 2003 when businessman Timothy Halter bought out a bankrupt nursing home chain.

For those less interested in finance, following is an exercise by an English writing student in the Xiao composition network.

My mother and I stood in line in the administrators help, carefully got into an inflatable rubber boat drifting. We just sit tight body, and the boat floated on fast forward. My mind was excited and nervous, leaning on her arms tightly, with the boat drifting happily shouting.

The topography is different speed of the boat will drift while fast, while slow, while we joked around while watching the stalactites of various shapes, sometimes obviously have no way looks like the front, but before the line to the near to can also be found that our boat was floating on the water, like a leaf in the wind, that scene is really stimulate it!

Boat floated for a while, I heard in front of ten thousand noisy sound of water, I said to his mother: Mom, probably in front of a waterfall! My voice hardly ever saw in our front there was a waterfall of white and shiny flew down from the roof, spray flying everywhere. I thought: Wow! It also may not get soaked the next? I quickly hid the boat head, like small ostriches to quickly see our boat sailing near the waterfall, our clothes were wet waterfall splashing water. My mother and you look at me, I see you had a good laugh.

After the waterfall, the gentle terrain and slowly, and our boat speed slowed down, and soon caught up with our boat in front of several boats, we also caught up behind the boat our boat, a few boat hit together, like playing bumper cars, like, really interesting.

Longmen Dong (Dragon Gate Cave), Sichuan Province

This Longmen is 8.8 kilometers of labyrinthic passageways within 1.3 by 1.8 kilometers of conglomerate limestone. The vertical range of 356 meters can be explored without ropes or ladders. The system has 4 major streams totaling 4.3 kilometers, 37 inlets and more than 60 waterfalls, 16 of which exceed 2 meters. The largest lake, Difeng Sump, covers 250 square meters. Narrow gorges are hemmed by round boulders fixed in a fine cement similar to concrete.

Shihai Dong Xiang (Xingwen Stone Forest), Sichuan Province

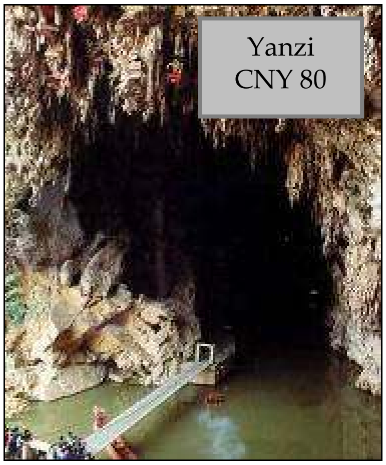
Xingwen Karst Geopark, covering roughly 156 square kilometers, is made up of four scenic areas, one of which is the Surface Karstand Ground Caves Scenic Area.

Shihai
CNY 90

Alufu
CNY 60

Alufu Dong (Alu Ancient Cave), Yunnan Province

Alufu was opened to the public in 1984, but its entrance theme park took another 13 years. The cave's 3-kilometer tour includes 18 chambers, a 800-meter river populated by blind cave fish, its resurgence, karst windows and a wealth of speleothems.



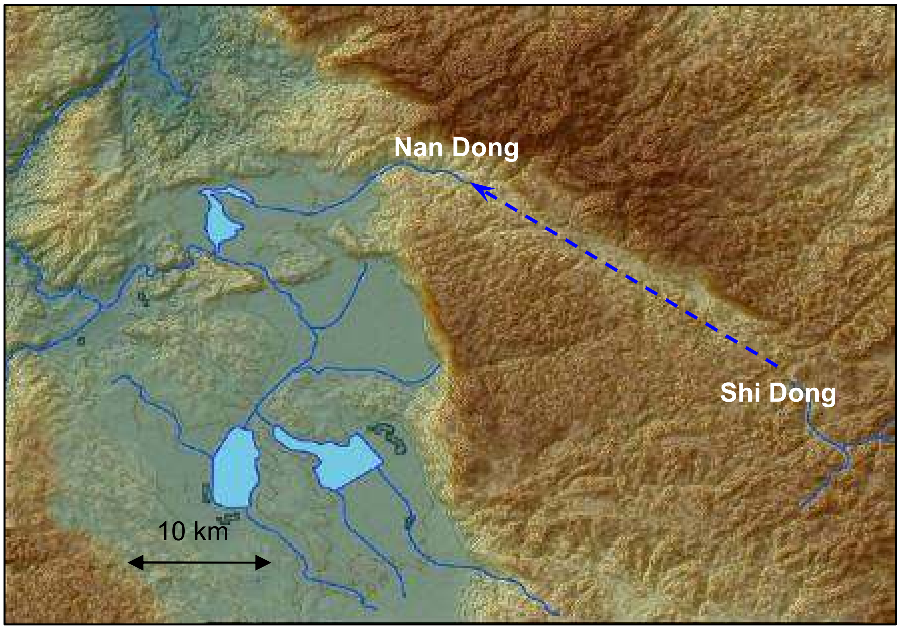
Yanzi Dong (Swallow Cave), Yunnan Province

The cave is named for swallows that nest in the portal. One can boat through 3 kilometers of darkness, a welcome reprieve from Chinese lighting. The main chamber -- lit -- is used for folklore performances.

Nan Dong (South Cave), Yunnan Province

The Yangliu River sinks below the entrance to Shi Dong (Rock Cave) and flows some 40 kilometers underground, dropping 800 meters and resurging at Nan Dong.

Shi Dong has been mapped for 3.8 kilometers, and Nan Dong, which contains two sumps, for approximately 2.



The connection was proven in 1969 when Chinese scientists engaged local farmers to haul 12,000 kilos of rock salt to Shi Dong. The network has since been shown to include several sinkholes and two additional tributaries. Mean discharge at Nan Dong 9.5 is cubic meters/second, but can exceed 40 in the summer. Tracer tests indicate velocities of up to 6.8 kilometers/day.

Nan Dong is a local tourist attraction where visitors can take a short boat tour illuminated by purple and green lights draped stalactite-to-sralactite.

Wolong Dong (Sleeping Dragon Cave), Yunnan Province

Jiuxiang Scenic Spot, 20 square-kilometers in area, is the largest karst cave cluster on the Yunnan-Guizhou Plateau. Sixty-six of the caves in the area are said to be profitably exploitable, a likely economic windfall for our electricians.

Wolong is entered through an immense portal, Terrestrial Gate, 120 meters above the cave floor, and a 9-rotations spiral staircase. The Maitian River is said to wind its way through the cave like a sleeping dragon. The cave's main feature is the Lovers' Waterfalls, which plummet 30 meters into a 10-meter pool. During heavy runoff, the cascades become one.

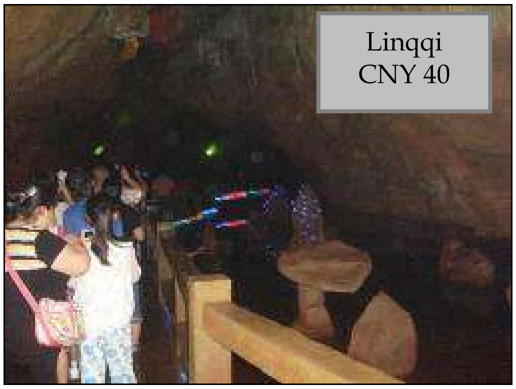
Wolong
CNY 120

Jackie Chan shot a scene for Myth (2005) here, jumping down the bigger of the twin falls and scrambling up the terraced pools.

途牛旅游网
Chuiyun
CNY 65

Chuiyun Tongtian (Heavenly River Cave), Zhejiang Province

This cave is visited by boat, from which visitors disembark to view side branches. An elevator lifts the craft over a waterfall.



Lingqi Dong, Zhejiang Province

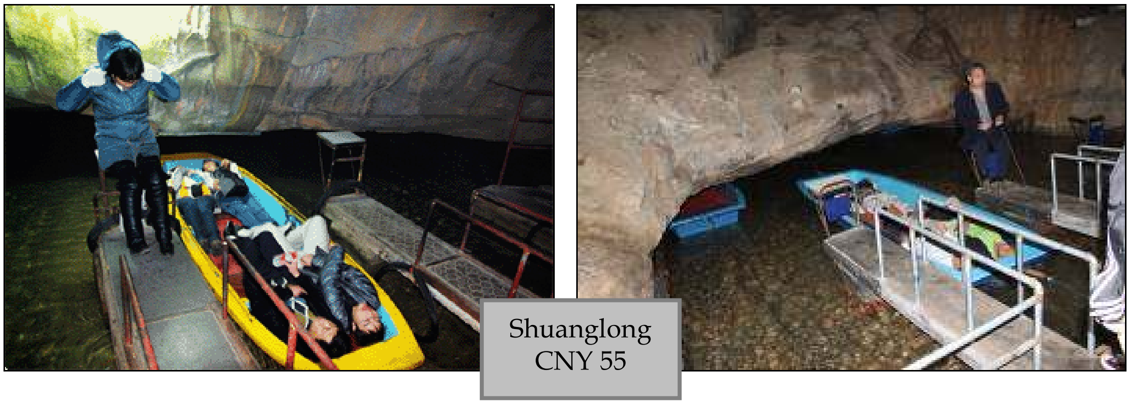
Opened to the public in 1980, Lingqi is comprised of three caves:

Qingfeng Cave, noted for its wind,
Aiyun Cave, noted for its fog,
Lingquan Cave, a 300-meter boat ride.

Shuanglong Dong (Double-Dragon Cave), Zhejiang Province

The cliff face around the cave entrance is decorated with characters dating from the Tang Dynasty. Inside is an inscription "Cave and Sky" by a calligrapher of the Song Dynasty, meaning, "The cave is a separate world with its own sky." An inscription on the cliff by a 20th century calligrapher says "36th Fairyland."

A wall of speleothems separate two chambers, the first having 1200-square-meters of flat floor. The 12-meter portal is filled by water to within 30 centimeters of the ceiling, forcing boaters to recline. The river exits the second chamber into a lake.



Ming Dynasty explorer Xu Xiake wrote of the cave,

> *A stone curtain hangs in the cave; by water and on foot, one can enjoy the wonders of the cave. And the light and shadow of the cave forms a unique scenery.*

Yaolin Dong (Yaolin Wonderland), Zhejiang Province

The cave is 28,000 square meters in area. For an additional fee, a 900-meter passage beyond the Buddhist temple in Yaolin Myth World Show Palace can be boated to Ancient Chinese Mythology World.

Yaolin
Wonderland
CNY 60

Yaolin
Palace
CNY 35

Fuyang Dong, Zhejiang Province

Discovered in 1983 by local farmers, the enterprise is budgeted at $6 million. Fuyang has a 23,300-square-meter chamber and a subterranean river yet to be explored and lighted.

Reflection

Let us reflect, if we may, on the visual aspect of underground rivers. Because the surface tends to be unruffled by breeze or current, that which is seen above is mirrored below, providing the sightseer a 2-for-1 visual. Cave photography frequently draws upon this duplicity.

And that's the issue of Chinese show caves -- too many colors times two.

China has rapidly emerged as a political and economic world power, and to this we must add, a show cave superpower..

Coauthors Dan Cave -- an apropos name for a cavern specialist -- and Dave Rowling suggest six principles of design in "Cave Lighting in the Early 21st Century," Australasian Cave and Karst Management Association Journal, June 200. The first two:

> *1. Do not over-light: A cave should be lit as a cave, and there should be no attempt to light the features as one would light an office or shopping mall. Subtle effects, the deliberate use of darkness, are often more effective and dramatic than the use of floods and "blanket" lighting. Of course, the under-lighting of a cave should not be at the expense of the safety of visitors.*
>
> *2. Create a theme: Rather than merely light a cave to "make it pretty," lighting should be used as a tool to illustrate aspects of cave development, history etc. Avoid the "Thousand Shawl Effect," i.e. the somewhat forgivable tendency to light every single pretty shawl in the cave. Rather, lighting should be deliberately sequential, with each scene leading logically to the next.*

The "Thousand Shawl Effect" sounds somewhat Chinese for good reason.

The U.S. National Park Service's candle-lit cave tours, a nostalgic concept for off-hours, are not suited for high-volume tourist trade. As noted by Cave and Rowling, safety cannot be compromised.

We simply wish that all cave rivers were marketed for their natural splendor, not their wattage.

Looking back, China wasn't always this way.

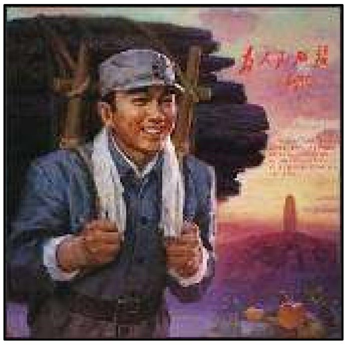
Take, for example, Yanan, Shaanxi Province, Mao's war-time headquarters with its "Farmers' Caves," dwellings cut layer upon layer into the yellow cliffs above the Loess Plateau.

Five to 7 meters deep, 3 to 4 meters wide and 2 to 5 meters high with semicircular fieldstone doorways and wooden sash-barred windows, the grottos are warm in winter, cool in summer, that do not usurp farmland.

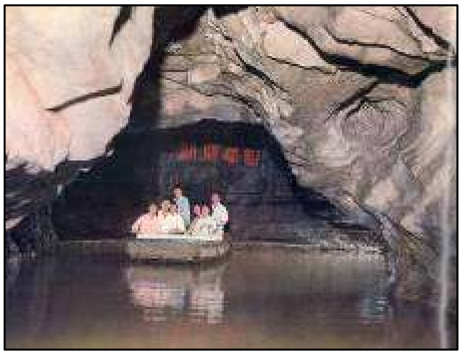
"To A Comrade" (1962) by Ko Pi-Chou

On the bank of the Yen River once we parted,
By the side of River Lo now we meet.
Together several days like body and shadow,
To each other our stories are too long to tell.
The wine we drink is Dragon Gate brew,
But the moon of Ch'iao Shan we both recall:
How we shared a mud cave for our lodging,

And how on mountain tops we learned as a group.



Modern cave-boaters near the Revolutionary war-time headquarters.



And here we must bid 拜拜, "bai bai" to our hosts and pole onward to other subterranean rivers.

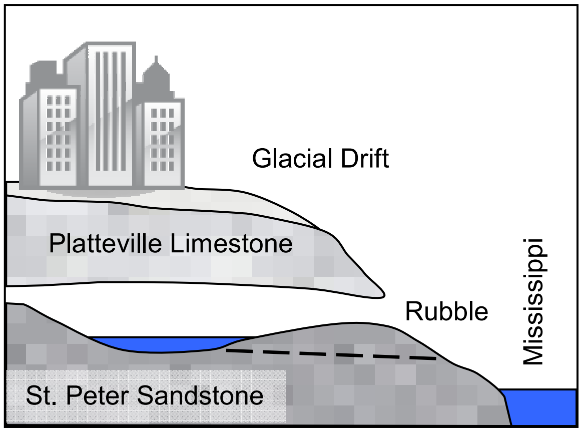
CHAPTER 54
THREE TALES OF TWO ST. PAULS

This chapter is about two St. Pauls; one on them a city, the other a river. The city is the setting for two stories, both sad, and the river, just one, but a happy one.

St. Paul, Minnesota

We will begin with the city, St. Paul, Minnesota, along the upper Mississippi. Before we develop the plot, however, we need to appreciate the local geology: soft St. Peter sandstone capped by Platteville limestone. Where cracks in the limestone allow infiltration, the sandstone below is rife for erosive piping. The photo shows the carbonate cap above the failing sandstone, the beach and floor, as it were, of an inland sea 450 years earlier.

Platteville Limestone above St. Peter Sandstone

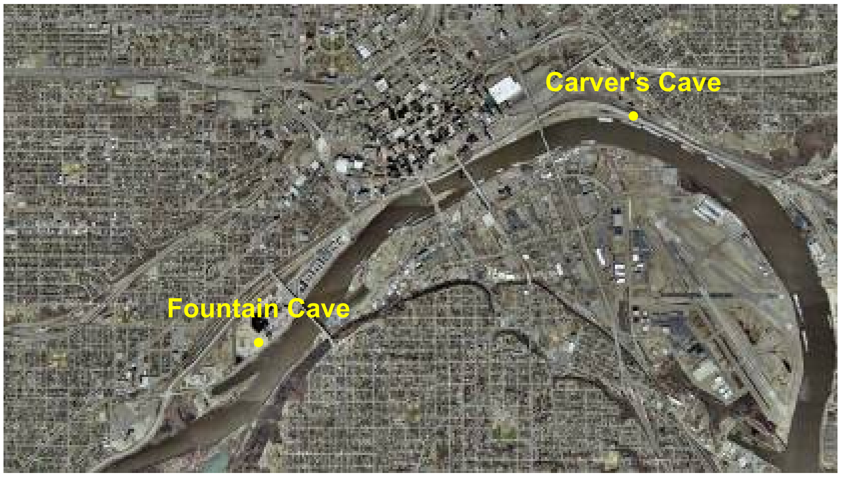


Where a sandstone pipe emerges on a steep slope -- a river bank, for example -- a cave may form with an internal lake maintained by rubble at the entrance.

In Chapter 62, More Hydropower from the Deep, we'll see how this stratigraphy has played out beneath the bed of the Mississippi, but in this chapter we'll look at tributaries.

We've stories of two sandstone caves: Carver's Cave located near the middle of the St. Peter stratum, and Fountain Cave, located near its top.

To the right are the locations on either side of downtown, modern St. Paul.



Carver's Cave

About 2,000 years ago, Native Americans created burial mounds on the sandstone cliffs known today as Indian Mounds Park, just east of the urban center.

Within the park lies Carver's Cave with its natural subterranean lake, but as we'll discover, we're not allowed within.

Indian Mounds Park St. Paul, Minn.

Scouting Minnesota for the British fur trade in 1766, Capt. Jonathan Carver examined the cave which would come to bear his name. From Carver's journal,

> *This cave I found to be a great curiosity, in a rocky mountain just by the bank of the* [Mississippi] *river. The mouth of the cave fronting the river* [is] *on an ascent near 45ø, the entrance about 10 feet broad and 3 feet high. I went in and measured the room upwards of 30 feet broad, and about 60 feet from the entrance of the cave* [to] *where I came to a lake. As 'twas dark I could not find out the bigness nor the form of it. The roof was about 20 feet high at the greatest elevation, the bottom clean white sand a little descending to the water from the mouth. I cast a stone which I could hear fall at a distance and with a strange hollow sound.*

A note on dimensions: As all of our Carver's Cave references employ Imperial units -- as opposed to SI -- we'll leave them as such for comparison.

> *I found many strange hieroglyphics cut in the stone some of which were very ancient and grown over with moss. On this stone I marked the arms of the king of England.*

Visiting the area four decades later, Lt. Zebulon Pike was told of the cave, but caprock boulders obscured its mouth.

Maj. Stephen Long was more persistent in 1817. The entrance was 8 feet wide and required one to lie down while entering. The cave was 60 feet deep, 7 feet high, slightly more than 22 feet wide and was filling with white sand under a small pool of stagnant water. In shape, the cave resembled a rounded baker's oven. Long's guide told him that the entrance had once been about 10 feet high and the cave itself, of greater length.

During the summer of 1823, now-Col. Long led an expedition up the Mississippi which paused briefly to further investigate the cave, but Long was told that the site was again inaccessible.

Indian agent Lawrence Taliaferro noted that in 1826, Dakota Chief Little Crow held a medicine dance above the "Big Stone Cave." In 1829, Taliaferro visited the cave for ice fishing, but found the pond to be frozen. Of significance is the fact that the cave was open.

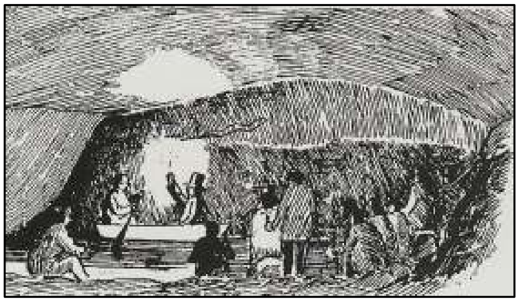
Geologist George W. Featherstonhaugh was informed in 1835 by local Native Americans that there had formerly been a large cave in the vicinity, but that "the rock fell in and covered it up."

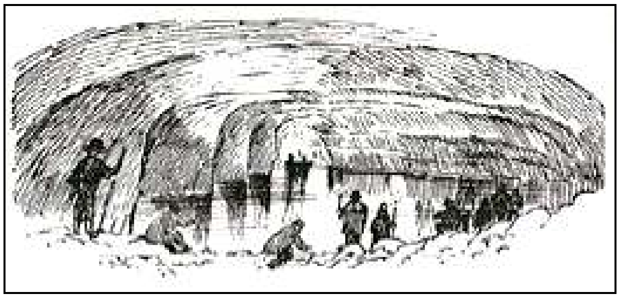
French cartographer Joseph N. Nicollet came to the site in 1837 and found the mouth obliterated by fallen stone. Freeing the entrance required two days.

In 1851, sand was being excavated from a chamber 40 feet wide and 70 feet long. The roof was low, a portion arching into a vault, and remnants of a bark canoe were found in the back.

In about 1857, Rev. E.D. Neill measured the entrance to be 39 feet wide and 5 feet high. The overall length was 117 feet with a maximum width of 45 feet and a height of 19 feet.

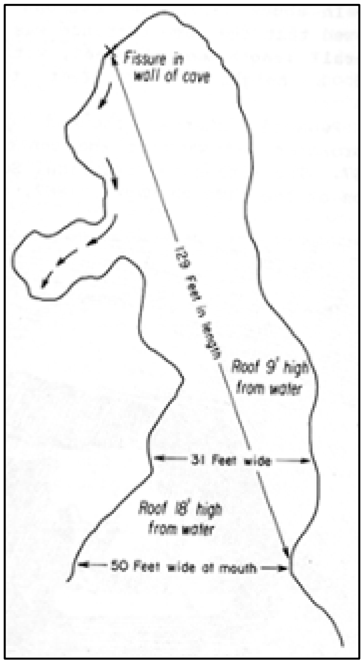
For the 1867 centennial of Carver's discovery, local druggist Robert Sweeny sketched dignitaries gathering stones from the margin of the pool, boating by candlelight and examining carvings of rattlesnakes on the ceiling.





Sweeny's map shows the cave entrance to be 50 feet wide and the cave, 129 feet in length. Much of the ceiling was about 9 feet above the pool, but the dome reached another 9, dimensions differing little from those to be made more than a century later. Sweeny's arrows may suggest flow toward a presumed submerged exit.

In the same period, a boat was left at Carver's Cave for the benefit of tourists. A former miner claimed -- falsely, given Sweeny's survey -- to have floated for a mile within.


Fissure in wall of cave
129 Feet in length
Roof 9' high from water
31 Feet wide
Roof 18' high from water
50 Feet wide at mouth

c. 1870

1875

Archeological attention in 1878 recorded four rattlesnake figures, two bear-like animals, outlines of men, birds, fish, turtles and one or two lizards. The cave entrance was 51 feet wide, 5 feet high, and had a depth of 113 feet. The greatest width within was 54 feet.

And now begin the troubles.

In 1869, the St. Paul and Pacific Railroad began to encroach upon the site because it lay along the line's right-of-way. The Saint Paul Dispatch, August 24 of that year, stated that railway expansion would necessitate removal of 75 feet of the bluff.

By 1885, a switchyard in front of the cave entrance passed more than 250 trains each day and some 22 feet of the cave entrance, containing Native American carvings, had been destroyed.

As lamented by Thomas Newson's Pen Pictures of St. Paul, Minnesota and Biographical Sketches of Old Settlers (1886),

> *The entrance to the cave is at present blocked by a railroad track. Its capacious chamber is filled with beer barrels. Its pearly stream has ceased to flow. It is slowly dying of civilization, and in a few years will be known only in history... and the landmarks of the past are obliterated by the swelling wave of the human race.*

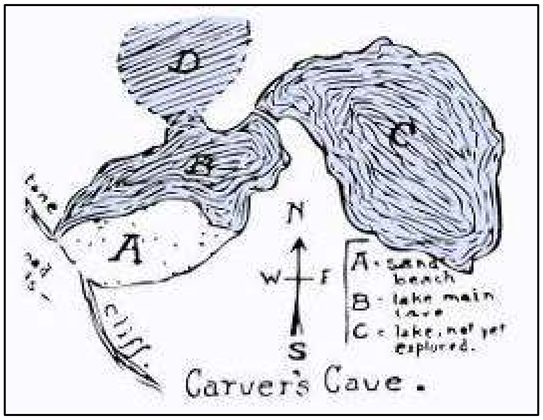
When the railyard was expanded that year, the cave's entrance was again reworked. From "Sculptures in Caves at St. Paul, Minnesota," De Lestry's Western Magazine 6:6 (1901),

> *The whole face of the bluff has been so changed that the oldest resident could not point out its former location with any degree of certainty, so that henceforth it will only be known in history as having once existed.*

By 1907, the entrance was again covered by rockfall.

In 1913, the railroad deemed the cavern suitable for tourism and plans were drawn for electric signage high on the cliff, visible to both the depot and river steamers.

As the entrance was again concealed, its location was located by tracing seeps from the foot of the bluff. Excavation was by horse-drawn scraper. When the cave's 12-foot lake was drained, the water level in Dayton’s Cave, 125 meters upriver, was affected. The well-publicized cave reopening of 1913 featured appropriately-photogenic Native Americans.

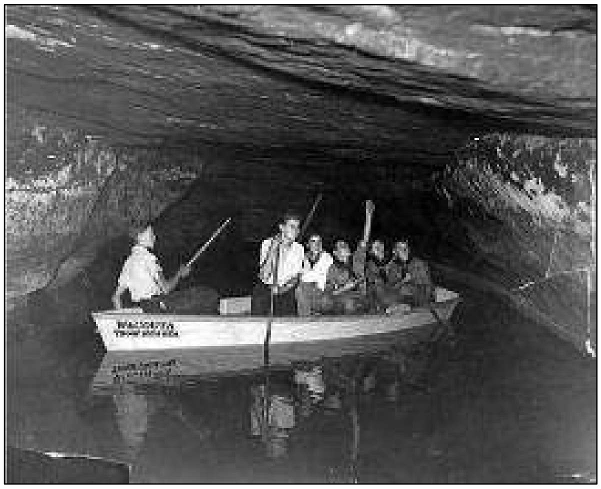


Two chambers extending 200 feet into the cliff were described during the rehabilitation. The outer chamber was 100 feet long by 40 feet wide by 12 feet high, about two-thirds covered by water.

Chambers C and D from the 1913 mapping are -- and remain --conjectural, reflecting probing of what seemed to be underwater openings. A scuba diver in 1991 thought he detected such holes, but his equipment prohibited passage.

As the tourist scheme never reached fruition and -- a loss for today's Indian Mounds Park -- there was little done to incorporate the cave into St. Paul's park system, the subterranean lake was gradually forgotten by the general public.

"To the general public," we said. Boy Scout Troop 4 was there in the 1930s.



Interest in Carver's Cave revived with the Centennial of Minnesota Territory in 1949, but the cave was not opened officially. Legend states that a local policeman unplugged the elusive entrance and flooded the nearby railroad track, causing the Northern Pacific to balk at restoration. Reports from the 1950s tell of the cave mouth being covered by 20 feet of dirt and rock.

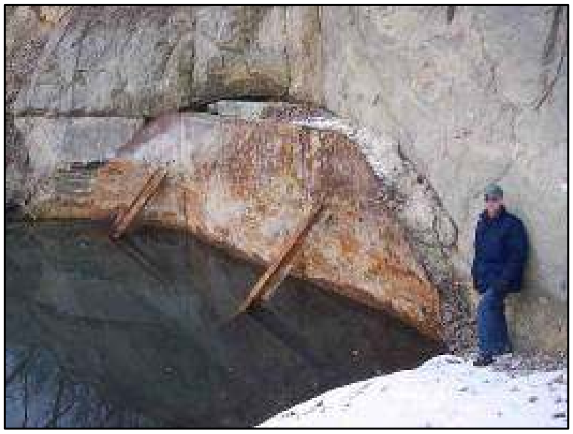
Carver's Cave was again dug open in 1977 by the City of St. Paul, but for research purposes only.

Greg Brick, author of Subterranean Twin Cities (2009), describes his 1995 sojourn.

> *To keep the water clear, I had to float on my back like a river otter so as not to stir up clouds of floor silt. I could see the opening to the second chamber below the surface and crudely felt out its dimensions with a stick. I could thrust a long pole through, so it seemed there was a room back there, but after ducking down into the chilly water, it became apparent that the hole was rather small. I considered holding my breath long enough to squeeze myself through into the room beyond (where there was hopefully an air pocket) but I didn't feel good about doing that sort of thing in such icy water when I was alone. The whole lake would have to be drained first.*

But like the attempt in 1913, draining the cavern was not to happen, the reason now being that the illegal deed would require more stealth than could be mustered.

Entrance to the subterranean lake is today barred by an iron gate, downstream rubble creating a backwater.



Over nearly two centuries, the mouth of Carver's Cave has opened and closed every few decades, several of the reopenings quickened by human intervention. It would be unfair to blame the railroad for the rockfalls, but it stands to reason that nearby earthwork likely hastened some instabilities.

The water level of Carver's cave has changed over time due to the elevation of outlet blockage. The reported length increase -- from 60 to 200 feet -- might not be uncommon in cases where time brings advancement in spelunking capability, but even the early explorers would have reached the back of this small cave and would have paced distances with reasonable accuracy. The increase may be due to wash-out of sand that once packed the rear.

Discharge at the cave mouth was approximately 100 liters/minute in the late 1990s.

Caver's Cave, complete with lake and Native American carvings, yet remains under St. Paul's Indian Mounds Park. We can only hope that the citizens of that city might one day reclaim the natural wonder.

Lost River Cave was discovered in 1938 by a road cut adjacent to Cave of the Mounds. To commercialize the discovery, an artificial waterfall was installed; passage were sprayed with fluorescent paints, black lights were added, the back end of the passage was blown open, and a tunnel was dug to reach an 1800's army fort.

After the venture folded, portions of the cave collapsed and the remainder was vandalized and filled with trash.

Beginning in 2001, local spelunkers have worked to restore the cavern to somewhat-natural conditions.

Fountain Cave

The tale of Carver's Cave is one of neglect, but at least one ending with a glimmer of hope that the iron gates will someday open.

The story of Fountain cave, 5 kilometers up the Mississippi from Carver's and on the same limestone bluff, is a story of malfeasance with nothing left to even iron gate.

Fountain Creek once drained into a sinkhole and flowed some 360 meters -- making it Minnesota's longest sandstone cavern -- to Fountain Cave, and then via a short ravine to the Mississippi.

The cave itself wasn't known until its mouth, long concealed by debris, was flushed open in 1811. Six years later, Steven Long reported a 3-meter-high opening discharging icy water into a flower-filled ravine. He ventured about 200 meters within.

In Narrative Journal of Travels (1821), Henry Schoolcraft noted,

> *Small pebbles of so intensely black a color as to create a pleasing contrast, when viewed through the medium of a clear stream. These, on examination, proved to be masses of limestone, granite, and quartz colored... from the gallic acid, with which the water, percolating into the cavern through beds of oak leaves of the superabundant forest, may be partially saturated.*

The oak leaves remind us of Leonardo da Vinci, who as noted in Chapter 8, upon being informed of a well yielding chestnut leaves, deduced the that the source must be a site growing chestnuts. Radical thinking.

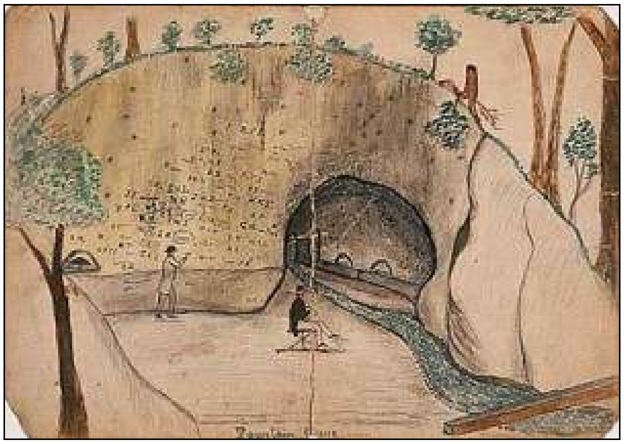
As recounted in the July 11, 1850, Minnesota Pioneer, July 4th revelers of 1831 explored Fountain Cave "for a distance of nearly one mile, when they reached a precipitous waterfall," a distance exceeding the cave's true length by a factor of four. The merry holidayers fired cannon from within the cavern, nearly collapsing the entry, a foretaste of things to come.

Missionary Peter Garioch recorded in his 1837 diary of hearing that "a soldier and two Indians formerly penetrated so far into this cave that they were never heard from any more."

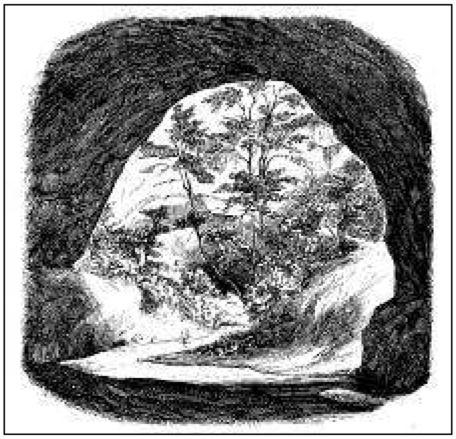
E.S. Seymour's Sketches of Minnesota, the New England of the West (1850) established that the cave was basically an unbranched tube, wholly within sandstone. Apart from four rooms successively decreasing in size, most of the passage was crawlway. The third room, the "Cascade Parlor," was named for its waterfall, less than a meter high. Seymour did not pass beyond the fourth room, but reported hearing a second waterfall in the distance which we can presume to have been the sinkhole.

Fountain Cave became a latter-19th-century tourist attraction featuring a 50-meter winding hall enlarged for access. A few accolades,

St. Anthony Express, July 5, 1851	*More beautiful than could be made with all the wealth of Astor.*
Minnesota Democrat, June 16, 1862	*One of the greatest curiosities and wonders of the West. It is one of the most beautiful spots in the Territory.*
Minnesotian, June 19, 1852	*The new retreat at the cave above town will be opened for visitors in a few days.*
Minnesotian, June 26, 1852	*Ice cream and other nice delicacies in the way of confectionery can not be had at "The Cave."*
Summer Rambles in the West (1853) by Elizabeth Ellet.	*A rustic pavilion stands in the woods where lights can be procured to enter the cave,... a marble temple,...* [and Fountain Creek,] *a shower of diamonds*

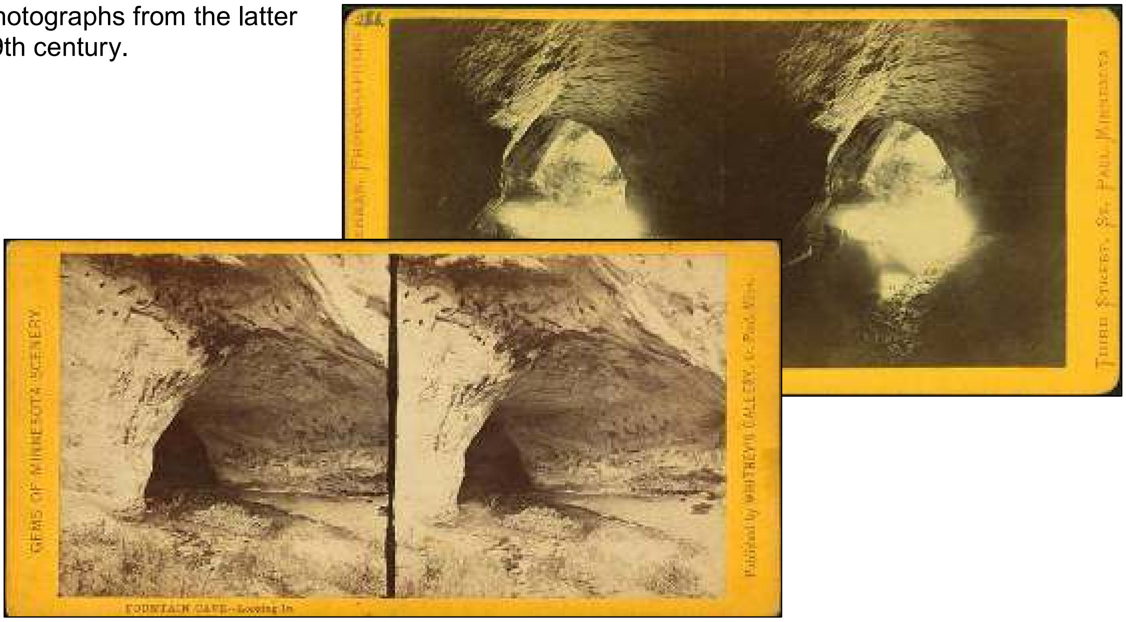


c. 1850



Harper's Magazine, July 1853

Photographs from the latter 19th century.


GEMS OF MINNESOTA SCENERY
Published by WHITNEY'S GALLERY, St. Paul, Minn.
FOUNTAIN CAVE--Looking In
THIRD STREET, ST. PAUL, MINNESOTA

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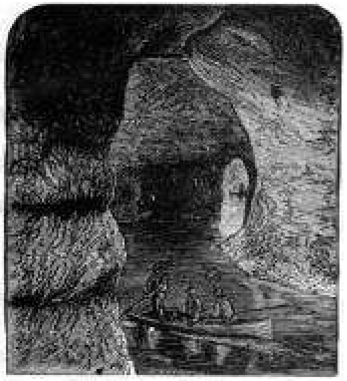
Exterior, c. 1870

Exterior, c. 1875

Interior, c. 1875

The interior illustration to the right, also c. 1875, is an engraving -- not a photograph -- for good reason; the stream was never navigable.



A longer reflection in the October 1857 Knickerbocker, or New-York Monthly Magazine is decidedly less exuberant.

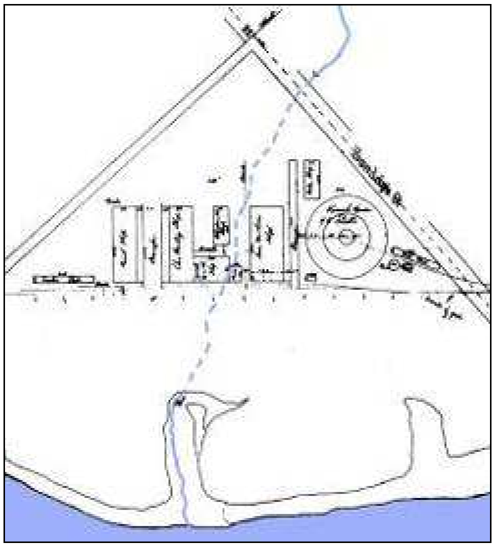
> *In its primitive simplicity it was doubtless a beautiful place, opening as it does in a deep glen near the Mississippi, and surrounded with luxuriant verdure. But that rapacity which exhibits itself in all the walks of life, has made its appearance here; and the spot, being "private property," now rejoices in a little seven-by-nine shanty, where, "for a consideration," you may obtain a "guide" and a tallow candle, and upon returning from your explorations, for another*

> *"consideration," some fiery brandy and a rank cigar. Aside from that, the place has lost much of its old charm, for during the summer months it is thronged with visitors daily; the paths leading to it are dusty and travel-worn, and the soft, white sand-stone walls are marred all over with the names of the Joneses and Browns who have honored "the Cave" in the "grand rounds." Why is it, by-the-way, that so many Americans seem to think it an imperative duty when they visit a place of any note, to leave behind them, for the edification of after-comers, through the instrumentality of the omnipresent jack-knife, their common-place names, and in the most staring capitals possible?*

To this point, we're half-way through what seems to be a typical American show cave history -- Victorian outings to be much later followed by an ethic of environmental awareness.

But as with Culver's Cave, Fountain Cave also had the railroad with which to contend.

It took just a decade after the arrival of the rail in 1869 before St. Paul's hub activity merited a regional repair facility and in 1880, the Chicago, St. Paul, Minneapolis, and Omaha Railroad began constructing such shops on the bluff above Fountain Creek. Lost wetlands deprived the cave of natural inflow and the shops claimed the sinkhole for that what the Dispatch, September 6, 1880, called "the shaft of the railroad company," i.e., sewage disposal.



1880's map: Shops in the triangle; Mississippi at the bottom; Sinkhole just above Randolph St.; Fountain Cave, the dashed line.

Below, a later view of the developed railyard.

Union Depot Railroad Yards, St. Paul, Minn.
NICHOLS EXPERT SCHOOL
N·X·S

Warnings were being raised regarding the cave below. In footnotes to The Expeditions of Zebulon Montgomery Pike (1895), editor Elliott Coues, wryly notes,

> *The New or Fountain cave is miles away, in Upper St. Paul, near the railroad bridge there, unless it has lately yielded to the triumph of art over nature and been effaced.*

Coues then quotes a Mr. Hill of St. Paul,

> *Within the past two years, however, sad changes have taken place. The St. Paul & Chicago Railroad, having condemned for their use the strip of land along the river bank, including the bluff or cliff in which is the* [Fountain] *cave, have dug it down and nearly destroyed it. But a narrow cavity now remains to mark its site. The pool or lake is gone, and the limpid stream that flows through it now supplies a railroad tank...* [But now] *sand heaped from railroad cutting has again backed up the water into a pool, the receptacle of all filth.*

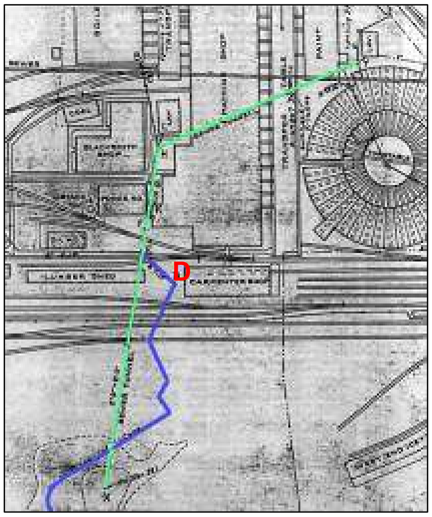
To the right is the cave entrance in approximately 1910, no longer the photogenic attraction of a few decades prior, now just a polluted trickle.

A railroad spur servicing the nearby Ford plant was built over the sinkhole in 1923, and absent the sinkhole -- albeit one of wastewater -- the cave's diminished inflow accelerated the cave's accumulation of debris.

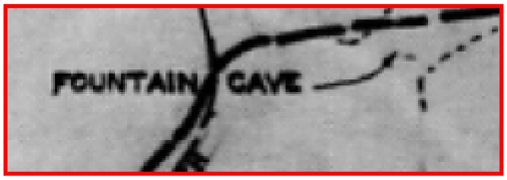
The green line on the 1939 St storm sewer plan shows the 3.4 by 0.8-meter tunnel then under construction to the river. Sanitary waste was transmitted to a treatment plant via a cast iron pipe affixed to the tunnel's ceiling.

The blue line indicates the lower half of Fountain Cave, the zigzags reflecting the line of survey. The roundhouse provides a point of reference with the map of the 1880s.

Railyard surface runoff was diverted to point D, "a manhole to a natural cave." Until the shops were demolished and the manhole sealed in 1960, the lower half of Fountain Cave continued to transmit local industrial runoff to the river.

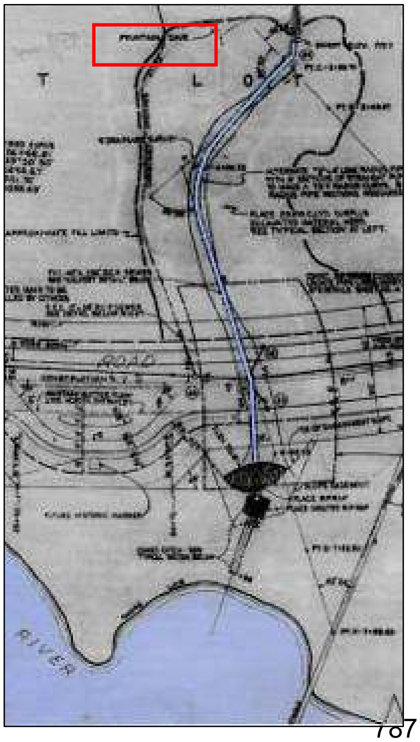


In 1960 the ravine was filled for construction of Shepard Road, making the cave not only inaccessible, but unlike Carver's Cave, unrecoverable.



Fountain Cave mathematically,

Pre-1830 Fountain Creek
Mid-1800s – Wetlands contribution
1880 + Sewage from railroad shops
1940 – Sewage from railroad shops
1940 – Upstream stormwater
1960 – Local stormwater
1960 – Cave mouth
1963 = 1 Historic marker



And even the historical marker is thought to have missed the original site by some 50 meters.

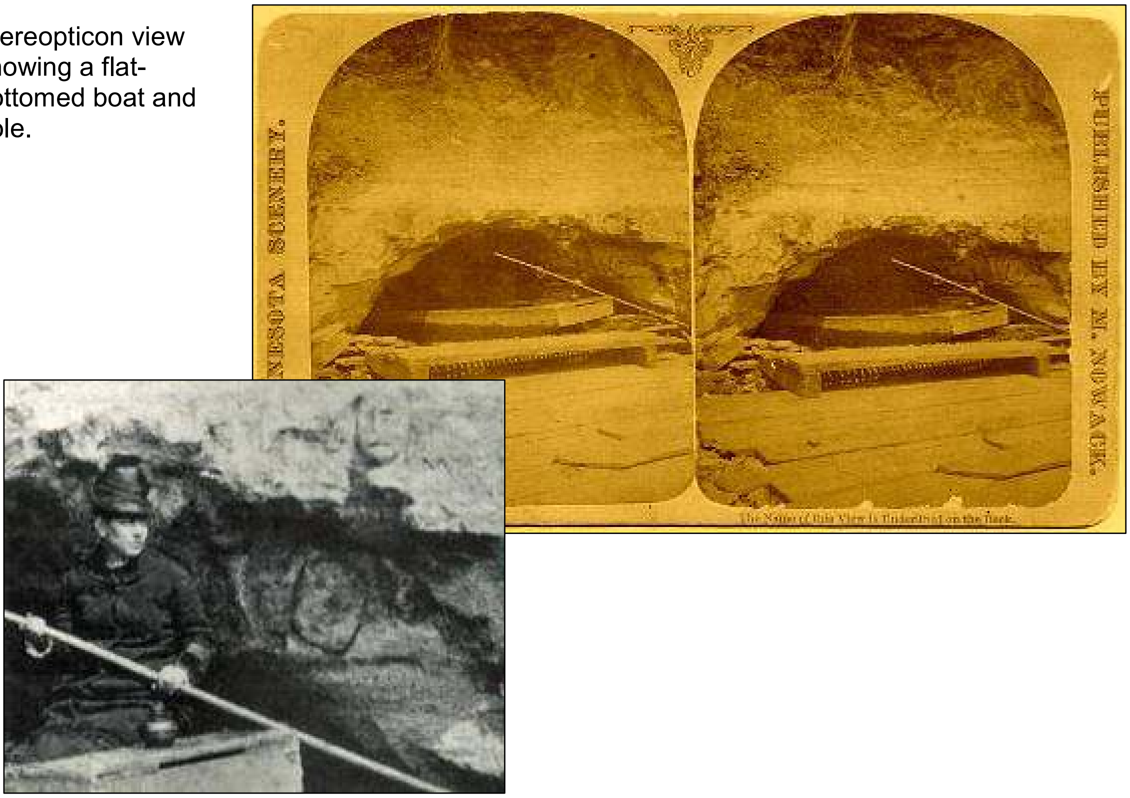
FOUNTAIN CAVE

Chute's Cave

Let us briefly move to St. Paul's Minnesota's neighbor, Minneapolis.

When S.H. Chute excavated a 2.5-meter tunnel to provide water to his Phoenix Four Mill in 1864, the project encountered a cave and was abandoned. A bulkhead built during 1875 excavation for a tailrace, however, made the suitable for sub-urban excursions. From the Saint Paul and Minneapolis Pioneer and Tribune, August 26 of the following year,

> *Chute's Cave -- A Boat Ride of 2,000 Feet Under Main Street.*
>
> *The mouth of the "Chute's Cave" is just below the springs, and the bottom of this cave is covered with about eighteen inches of water. For the moderate sum of ten cents you can take a seat in a boat with a flaming torch at the bow, and with a trusty pilot sail up under Main street a distance of about 2,000 feet, between pure white sandstone, and under a limestone arch which forms the roof. It is an inexpensive and decidedly interesting trip to take.*

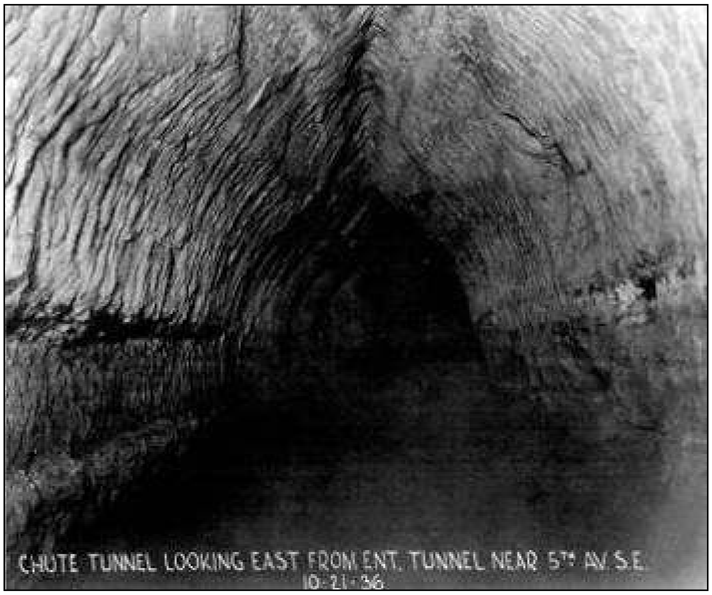


Stereopticon view showing a flat-bottomed boat and pole.

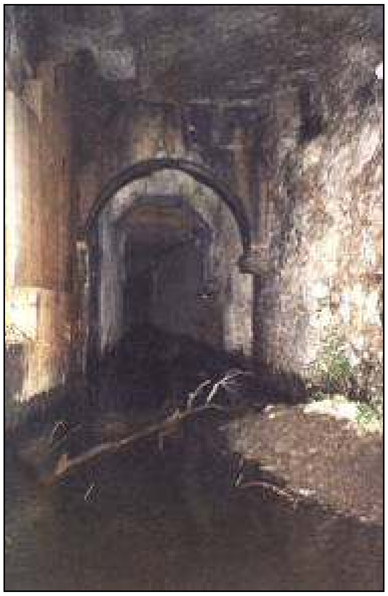
From the Saint Paul and Minneapolis Pioneer and Tribune, December 1, 1889,

> *But a few years ago not a day passed that did not bring in visitors. A stream of water ran the whole length of the cave, and for the small consideration of a dime, a grim, Charon-like individual would undertake to convey, in a rude sort of a boat, all visitors, who were inclined, for the distance of a quarter or a mile or thereabouts into the gloomy passage.*

The article's "a few years ago" refers to 1881, when a portion of the cave collapsed, taking Main Street with it. The remaining cavern was trussed with wooden beams and closed to the public.


CHUTE TUNNEL LOOKING EAST FROM ENT. TUNNEL NEAR 5TH AV. S.E.
10-21-36

1936



2001

Closed, but not forgotten to the authorities, as evidenced by the Minneapolis Tribune, October 5, 1961, inclusion as a fallout shelter for downtown workers.

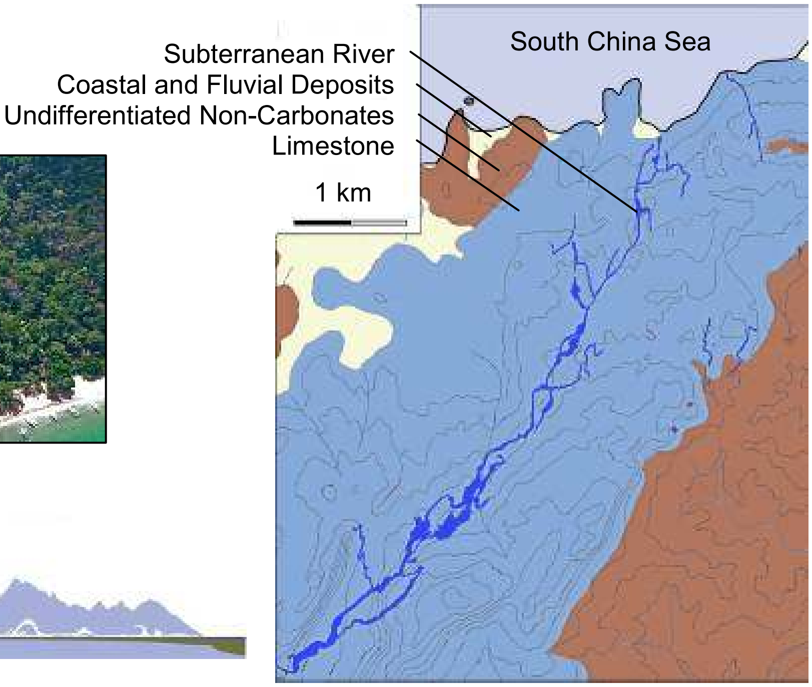
Chute's Cave wouldn't have saved many, however, as radioactive seepage would have continued to drip from the nuclear wasteland above.

FALLOUT SHELTER

Even without fallout, such caverns can be can be deadly. A man died in 2009 when the tunnel he was exploring in Minneapolis-St. Paul filled with rainwater.

St. Paul River, Palawan, the Philippines

And now, a happier story from the Philippines where the St. Paul River flows underground to the South China Sea.



Outlet to the sea.

At 8.2 kilometers in length, the St. Paul was the world's longest navigable underground river until the discovery of the Son Trach in Vietnam.

Ex World Record

Longest Navigable Underground River
8.2 km

Outflow daylights 200 meters from the coastline and tides make 6 kilometers of the cavern an underground estuary.

The subterranean river was long believed by locals to be a place of ill omen. There is no documentation of when the underground river was first explored, but painted crosses yet on the walls are said to be markings of Italian priests

The earliest publicized reference to the channel was in an 1887 tour summary by University of Michigan Prof. of Zoology Dean Worcester. “If accounts are to be believed, [there exists] a lake opening to the sea by a Subterranean River.”

Worcester was to become Secretary of the Interior of the Philippine Islands, 1901-1913, during the American rule. From his The Philippines Past and Present (1914),

> *A range of limestone mountains ends at St. Paul's Bay on the west coast of Palawan... Beneath this range lies the scenic wonder of the Philippines, the famous Underground River, up which a ship's launch can run for more than three miles to what is called the "stone pile," caused by the falling of a great section of the roof. One may climb this obstruction, and utilizing*

> *native boats dragged over it by my party in August, 1912, may continue for a distance of half a mile, to a point where the roof of the cave drops to the level of the surface of the water, and further progress becomes impossible.*

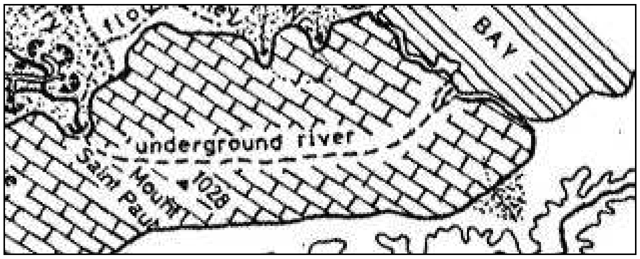
The stone pile and the roof drop call into question the one-time world record claim of 8.3 navigable kilometers, but one might argue that the record book doesn't say "continuous."

> *A trip up this river is an experience never to be forgotten. There is no danger of getting lost, as the three short side passages which run off from the main cavern all end blindly. The channel has been mapped by the Coast and Geodetic Survey and is plainly marked at all critical points.*
>
> *One's launch should be provided with very powerful acetylene lights so arranged as to give a general illumination. Stalactites and stalagmites occur in every conceivable form. There are vaulted chambers which are full of them, and there are long straight passages which lack them and have roofs and walls resembling those of a New York subway. In places the cavern is full of edible-nest-building swifts and of bats. The air in the main passage is fresh. During the rainy season water runs from the roof in many places, and one must expect an occasional shower bath, but this is the only discomfort attendant upon the trip.*

As noted in the New international Encyclopedia of 1918,

> *It has been explored by the Philippine government from its mouth to a point about 3 miles inland, where the roof of the cavern descends to the water's level.*

It wasn't until 1973 that formal geological study began, when D. Balazs of the Geographical Research Institute of the Hungarian Academy of Science and Filipino companions carried out the first documented exploration. A portion of Balazs' map,



Australian speleologists further explored in the early 1980s,

Italians began explorations in the later 1980s and have extended the surveyed passages (many of which are dry) to 25 kilometers. A sample of the findings: "Recent Explorations in the St. Paul Karst (Palawan, Philippine)," Proceedings of the International Congress of Speleology 15:3 (2009) by Antonio De Vivo, Leonardo Piccini and Marco Mecchia.

> *Cin Galleries (length 1750 m) - This was the most important discovery made in the PPSR* [Puerto Princesa Subterranean River] *during the 2007 campaign. The main gallery is reached through a flooded branch passage, beginning around 1.5 km from the entrance on the left hydrographic side of the main tunnel. The flooded tract is a small size gallery, with a short low passage that is completely closed when the tide is high. Beyond this tract, a wide gallery with a sandy floor is reached, which runs parallel to the main collector. To the S, the gallery continues among large concretion deposits and sand and mud in-fills, and finally reaches a chamber connected to the Navigator's Chamber. Towards the N, the gallery continues wide for ~200 m and then splits into two branches.*

In 2011, bathymetric analysis was carried out from the entrance to Rockpile -- Worcester's "stone pile" -- in which water level and temperature were monitored for 6 days at three sites. Net sea water flux averaged 0.8 cubic meters/second; that of opposing fresh water, just slightly more.

But the most significant work has been outside of the cave.

By the 1970s, the environmentally-disastrous consequence of wholesale logging began to be recognized, culminating in the cancellation of timber license agreements in 1992.

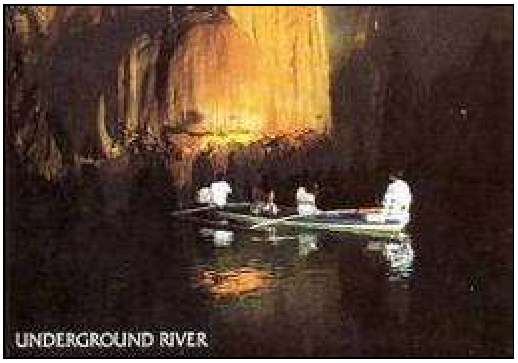
Many conservation efforts came quicker, however. The province was declared a Fish and Wildlife Sanctuary in 1967 and in 1971, the St. Paul Subterranean River National Park was established.

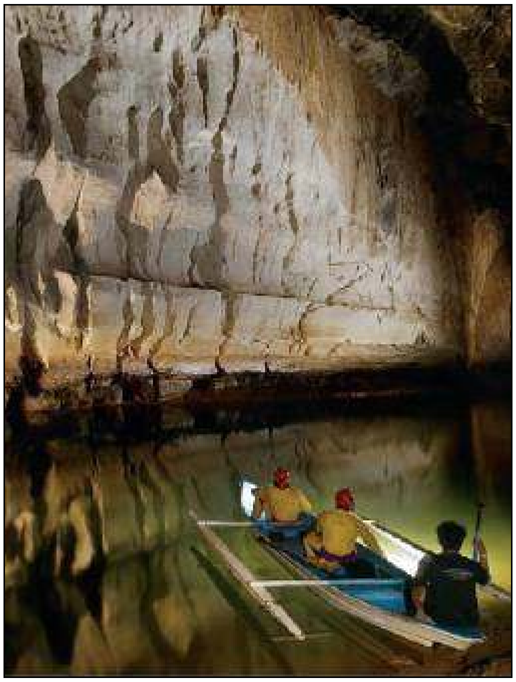
When in 1992, nearby Puerto Princesa City assumed management responsibility, the park was renamed "Puerto Princesa Subterranean River National Park" and the thus cave became the "Puerto Princesa Subterranean River."

An outrigger tour 1.5 kilometers in length-- all that's allowed by the officials -- passes through a cave chamber with a 65-meter ceiling -- there one twice as high further within -- and attracts some 800 visitors daily.

Puerto Princesa
Subterranean River
200 pesos

A few photos.





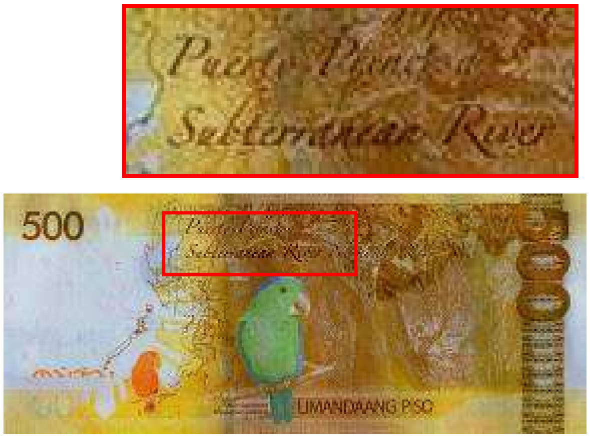
Note the limestone strata to the left.

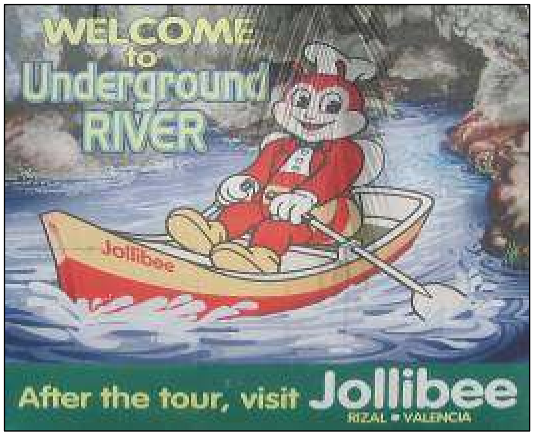
In contrast with the garish illuminations of many of the world's show caves, Puerto Princesa provides visitors a true cave experience.

A few of the visitors.

Welcome to
Puerto Princesa Subterranean River National Park
Underground River
Puerto Princesa City, Palawan, Philippines

After the tour, a 500-peso subterranean river note would buy a hungry family of five each a Jollibee Double Yum w/ cheese, regular fries and regular soft drink.


Puerto Princesa
Subterranean River
500
LIMANDAANG PISO


WELCOME to Underground RIVER
Jollibee
After the tour, visit Jollibee
RIZAL • VALENCIA

Puerto Princesa's honors for environmental stewardship are many.

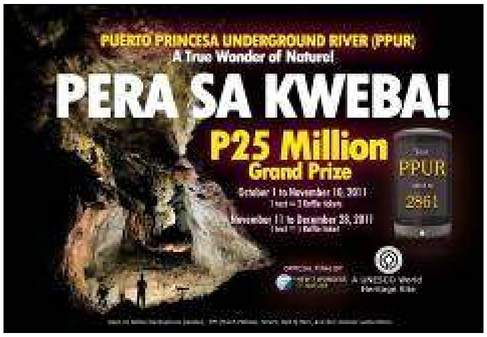
In 1996, the City of Puerto Princesa was officially the “Cleanest and Greenest Component City in the Philippines”

The park was nominated for UNESCO World Heritage status in 1991, but its 5,735 hectares were deemed too small for comprehensive conservation. After land preservation measures brought the total to 20,202 in 1999, the park was awarded the distinction.

The National Geographic named the province as one of the "20 Best Trips of 2011."

And in that same year, the Puerto Princesa Underground River was voted one of the "Seven Natural Wonders of the World."

NEW
WONDERS OF NATURE
VOTE NOW PUERTO PRINCESA UNDERGROUND RIVER


PUERTO PRINCESA UNDERGROUND RIVER (PPUR)
A True Wonder of Nature!
PERA SA KWEBA!
P25 Million
Grand Prize
PPUR
2861
A UNESCO World Heritage Site

"Money in the Cave," a get-out-the-vote promotion

St. Paul River of the Philippines marks a victory for both environmental quality and economic development.

Conclusion

There are underground river stories that dismay and underground rivers stories that inspire. Tales of St. Paul include both.

CHAPTER 55

A SUPERFLUITY OF SURFICIAL STYGIAN STREAMS

Superfluity: an excessively large amount or number
Stygian: of or relating to the River Styx

Our journey has been -- and for most part, will continue to be, -- a subterranean voyage.

The Peloponnesian River Styx of Chapter 1 was named by someone having classical fun with the karst features encircling Lake Pheneus. If there was a pre-Hellenist surficial Styx, we can't be certain, but the Arcadian River Mavroneri is the modern supplication for a Stygian tourist destination.

In Chapter 50, we inspected photos of the Mammoth Cave River Styx. In Chapter 51, we visited the Jenolan Caves River Styx. In Chapter 60, we will visit Ukrainian and British Styx-named excavations. In Chapter 63, we'll meet the River Styx of Oregon Caves. There's also a River Styx Cave in Texas. One comes to anticipate, in fact, that the boatable chamber of any tourist cave will be so named. It's as common as the gift shop.

In this chapter, we will drift a point or two off course to enumerate like-named rivers on the earth's surface. Daylight diversion seems allowable, as all are namesake to the river beneath.

The "River Styx" or the "Styx River?"

As footnoted in Ritchie’s Fabulae Faciles, A First Latin Reader (1903) by John Kirtland,

> *Stygis fluminis. We say "River Styx," but "Mississippi River."*

Why is this so?

The more-common word-order in naming geographic features is specific identifier, followed by the feature class, but the order is reversed for certain classes.

Specific/Class	Class/Specific
Indian Ocean Bearing Sea Atlantic City Sahara Desert Baja Peninsula Suez Canal Okefenokee Swamp Mississippi River	Cape Fear Port Angeles Fort Hood

The order is sacrosanct for most classes. We don't say "Desert Gobi" or "Wayne Fort." The order for lakes, however, is less fixed. We've both "Crater Lake" and "Lake Michigan."

River names can likewise be in either manner, though the preponderance, like the Mississippi, are in specific/class sequence. Rivers in the U.S.G.S. Geographic Names Information System named in class/specific order include the River Lethe in Arkansas, the River Deshee in Indiana, the River De Chute in Maine, the River Meadow Brook in Massachusetts, the River Raisin in Michigan, the River Rouge in Michigan, the River Gayoso in Missouri, and the River Laurel in West Virginia.

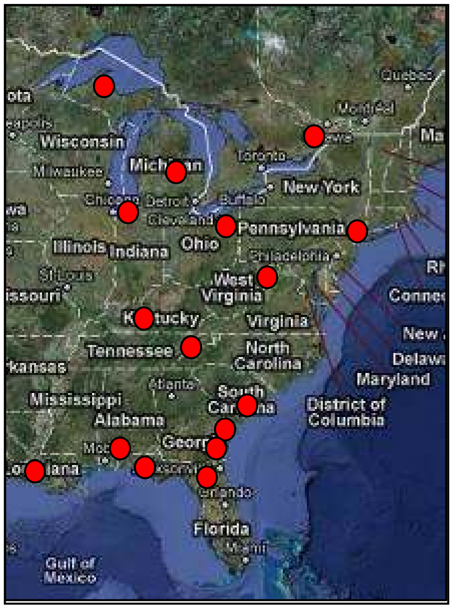
Stygian rivers go both ways -- "River Styx" and "Styx River," according to the mapmakers. For our use, however, we much prefer the former. Inspecting the maps, "River Styx" outnumbers "Styx River" by a factor of 2:1. By Internet hits, it's 6:1.

If we need precedent, Nathan Bailey included "River Styx" in The Universal Etymological English Dictionary (1731).

The general/specific word order has a classical ring, as indeed it should. The Styx mustn't be taken casually.

If we're accused of etymologic elitism, we concur. Charon's river is indeed a cut above (or below, as it were) plebian waterways.

So let's look at the Stygian rivers.


Quebec
Montreal
Wisconsin
Michigan
Milwaukee
Toronto
New York
Chicago
Detroit
Buffalo
Cleveland
Pennsylvania
Illinois
Indiana
Ohio
Philadelphia
St Louis
West Virginia
Missouri
Kentucky
Virginia
Tennessee
North Carolina
Arkansas
Atlanta
South Carolina
Mississippi
Alabama
District of Columbia
Maryland
Georgia
Louisiana
Orlando
Florida
Miami
Gulf of Mexico

North America

North America has more than its share of surficial rivers named Styx, 23 of which we'll briefly visit. The map is limited to those on the eastern side for reasons of scale.

Alabama's Styx lies on the Gulf Coast.

Whitehouse Forks
3

Tributary to the Perdido River, Alabama

Styx River Water World

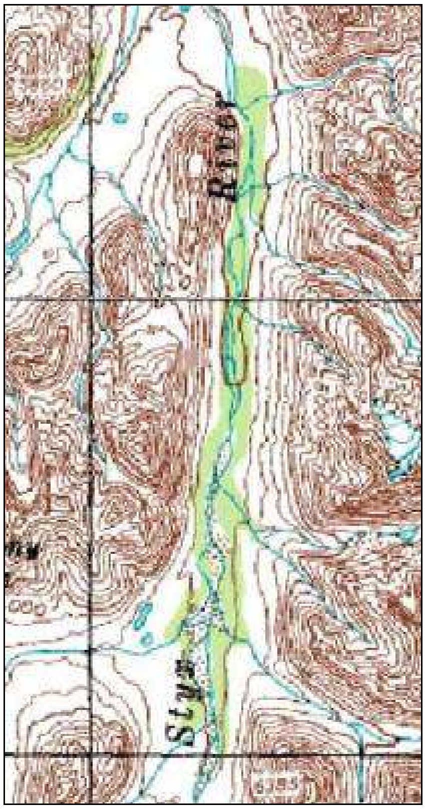
Robertsdale, Alabama

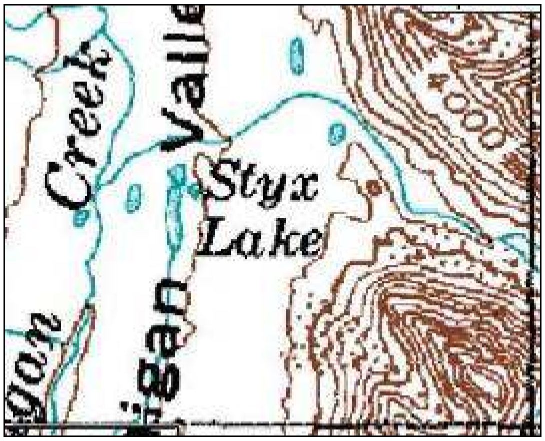
This 50-kilometer river in southwestern Alabama flows into the Perdido River which in turn empties to the west of Pensacola. Given the hurricanes, native population, and swampy environment, Spanish explorers would have indeed felt "perdido," lost. As only Hades could lie up-river, they named it named it the Styx.

In 1951, an erudite employee of the Alabama Highway Department posted a closure sign at the river crossing, "Charon Retired." The March, 9 Cass City Chronicle reported that local motorists were puzzled.

The resort infrastructure includes the expected, of course, but here there's also the Styx River Water World. Unfortunately, much of its statuary has been vandalized since the attraction was abandoned in 2001.

Alaska's River Styx would have been an exploratory challenge as well.



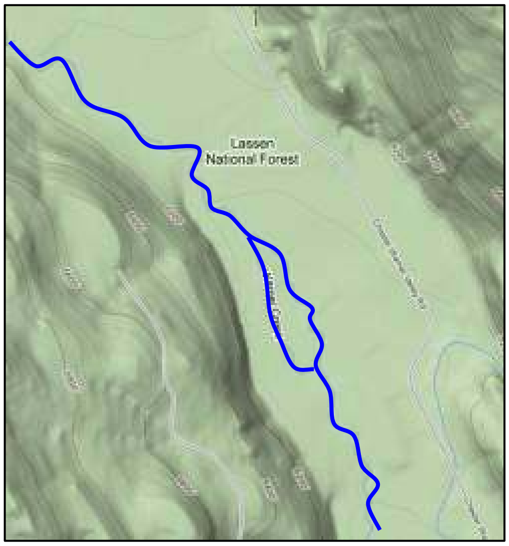


Styx River and Styx Lake, Alaska

Fed by glaciers in the Alaska Range, the river and lake were named by the U.S. Geological Survey in 1898 after the river of Greek mythology.

Although all Stygian rivers share the same etymology, these are the only instances so documented by the U.S.G.S.

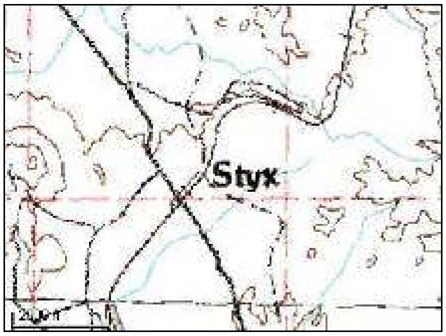
California adds a pair of rivers to our list, one in the north, the other in the south.



Lassen Volcanic National Park, California

To the west [of Drakesbad Resort]*, the solfataras of the Devil's Kitchen hiss in the lava-walled "Canyon of a Thousand Smokes," through which flows a tiny stream called the Little Styx.* -- Federal Writers' Project, California A Guide to the Golden State (1939)

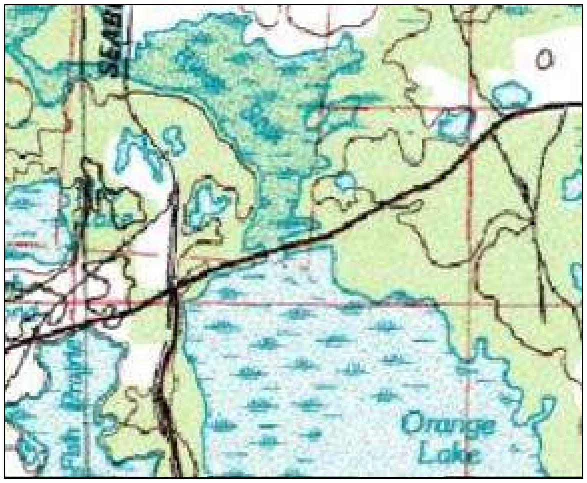
Despite its smoky classical correspondence, the Little Styx has since been renamed Warner Creek



Mojave Desert, California

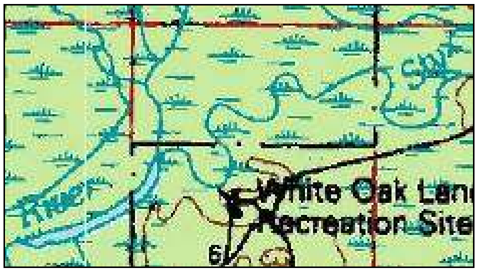
This Styx is easier mapped than found. We'll pass this way again in Chapter 86, The Rio San Buenaventura.

Florida likewise has two.



Alachua County, Florida

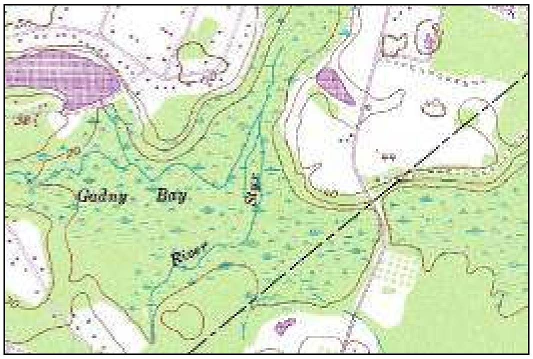
River Styx near Gainesville connects Newnan's Lake with Orange Lake through a cypress swamp in which paddlers should be alert for alligators. An "Outstanding Florida Water," Orange Lake contains floating islands, a phenomena discussed in Chapter 74, Railroads and Incrusted Lakes.



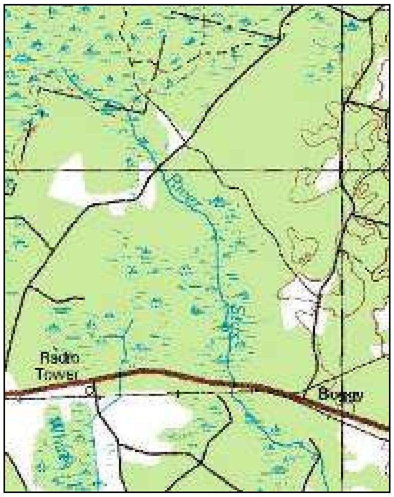
Liberty County, Florida

The Gator State's western Styx flows to the Apalachicola River through the state's least-densely populated county.

The state of Georgia has two small rivers named Styx, both flowing into swamps


Gadny Bay
River
Styx

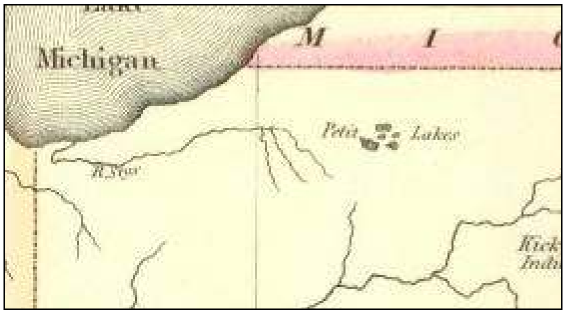
Savannah River Watershed, Georgia


Radio Tower
Buggy

St. Marys Watershed, Georgia

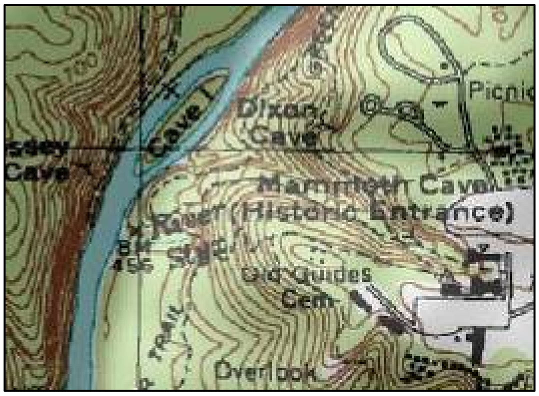
Along the southeastern fringe of Okefenokee Swamp

The River Styx of Indiana Geographical, Statistical, and Historical Map of Indiana (1822), Lucas Fielding, appears to be the east arm of the modern Little Calumet River, a system reasonably preserved near its La Porte headwaters, but increasingly obliterated toward Gary.

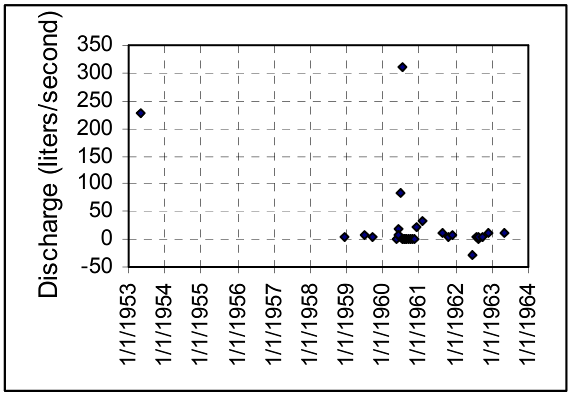

Michigan
M I
Petit Lakes
R.Styx

La Port
Gary

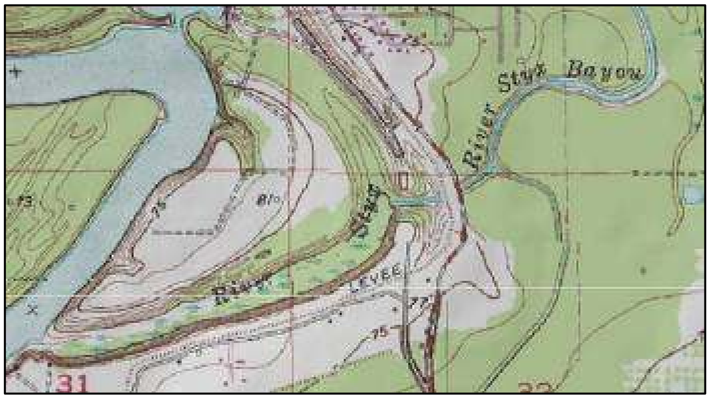
As noted in Chapter 50, Mammoth Cave, Kentucky's subterranean River Styx makes a short, sunlight escape to the Green River. As the flow is typically just a few liters/second, the "river" designation is but honorific.

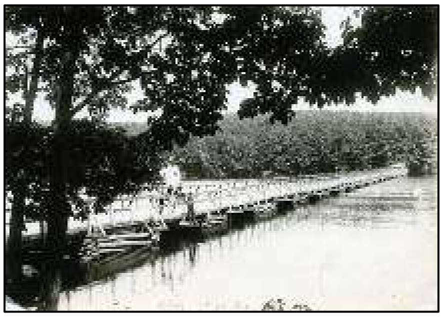

Dixon Cave
Cave
Cave
Picni
Mammoth Cave (Historic Entrance)
River Styx
BM 456
Old Guides Cem.
TRAIL
Overlook

As can be seen from the plot, stream gaging on the Styx has been sporadic and short lived, but the record does catch one instance of reverse flow brought about by flood level in the Green.

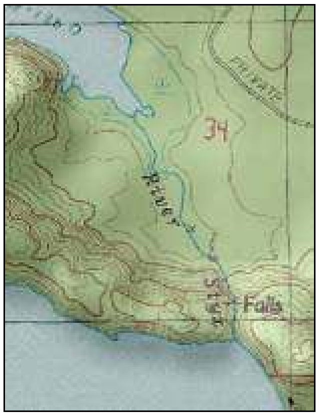


Louisiana's River Styx Bayou flows into the Ouachita River. The U.S. Army Corps of Engineers proposes to reduce flooding from interior ponding by an additional pumping station adjacent to River Styx Bayou and improved levee alignments.

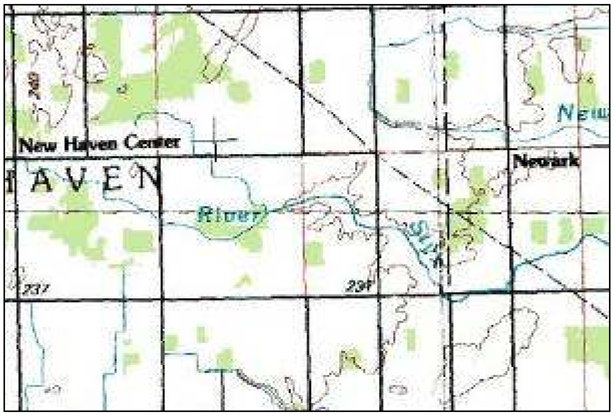

River Styx Bayou
LEVEE
31


Crossing Louisiana's River Styx, circa 1900

Michigan adds two rivers to our collection.

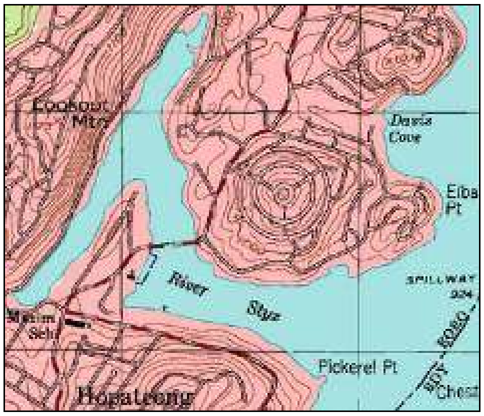

34
River Styx
Falls

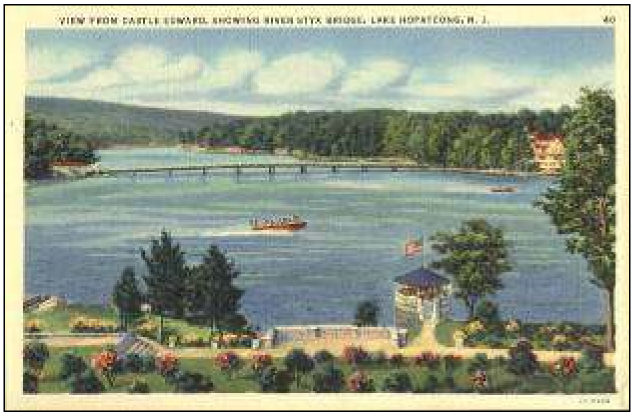
Ives Lake Outlet, Marquette County


New Haven Center
HAVEN
New
Newark
River
Styx

Montcalm County

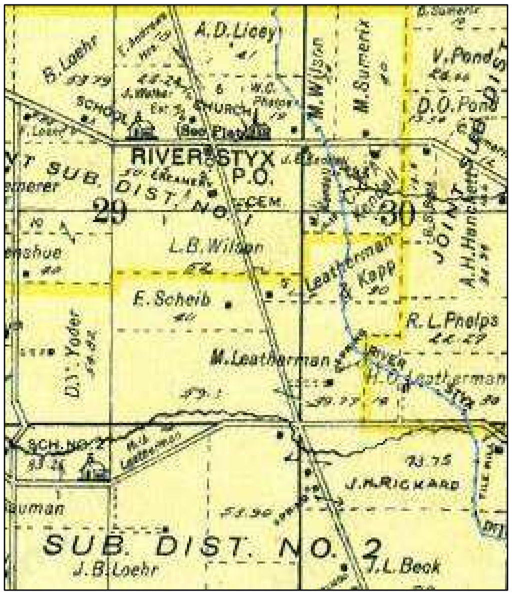
The bay at Hopatcong, New Jersey, is not a river, but none the less called River Styx.


Lookout Mtn
Davis Cove
Elba Pt
River Styx
SPILLWAY 924
Pickerel Pt
Hopatcong
Chest


VIEW FROM CASTLE EDWARD, SHOWING RIVER STYX BRIDGE, LAKE HOPATCONG, N. J.
40

Ohio's River Styx is also a community.

RIVER STYX
MARKET
Coca-Cola


A.D. Licey
B. Loehr
M. Wilson
M. Sumerix
V. Pond
D.O. Pond
SCHOOL
CHURCH
RIVER STYX
P.O.
CEM.
SUB. DIST. NO. 1
29
30
L.B. Wilson
Leatherman & Kapp
JOINT SUB. DIST.
A.H. Hanchett
F. Scheib
R.L. Phelps
D.J. Yoder
M. Leatherman
Leatherman
SCH. NO. 2
J.H. RICKARD
SUB. DIST. NO. 2
J.B. Loehr
J.L. Beck

Atlas of Medina County, Ohio (1897)

Legends vary regarding the name.

The river was named to warn citizens away from Bear Swamp and its bootleggers, robbers and renegades.

Settlers, trying to burn out a rattlesnake den, destroyed the forest and all the game in it. Discouraged and faced with starvation, they nicknamed the settlement, River Styx.

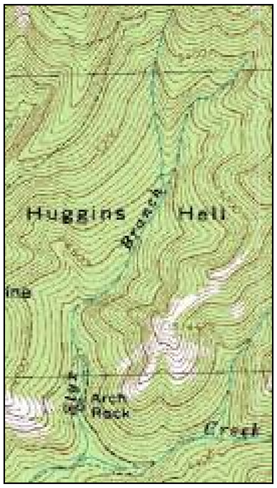
Local residents once kept the Cleveland medical colleges supplied with laboratory material by grave robbing.

Indians called the river "Sticks River" because of the difficulty of paddling canoes on the small, cluttered waterway.

The town was said to be the site of Ohio's first match factory where "fire sticks" were manufactured.

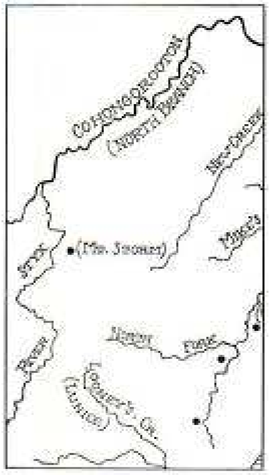
Neither of the last two account of a change of spelling, however.

But we must move on.


Huggins
Branch
Hell
ine
Styx
Arch
Rock
Creek

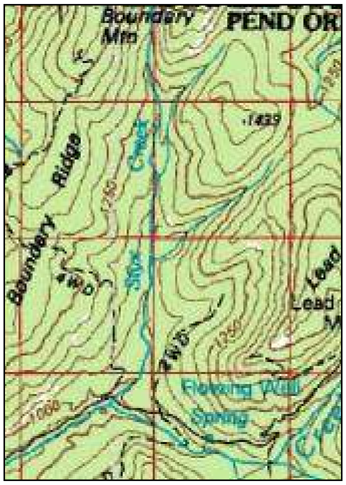
Sevier County, Tennessee

As confirmed by the U.S. Geological Survey, the Styx flows through Hell.


Cohongoroota
(North Branch)
New Creek
Styx
(Mt. Storm)
Mines
North Fork
Patterson's Cr.

Grant County, West Virginia

From "Fairfax Lands along Patterson Creek, 1746-1781." This River Styx is now called Stony River.


Boundary
Mtn
PEND OR
Ridge
Boundary
Creek
Styx
Lead
4WD
Flowing Well
Spring

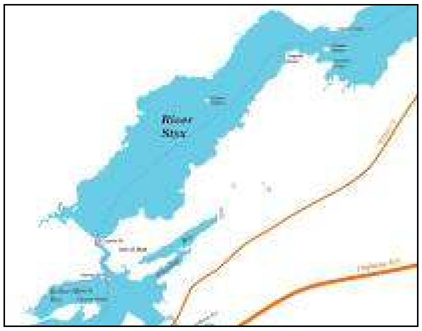
Orellie County, Washington

An international waterway.

Camp Styx, South Carolina, a World War I Army base, returned to life in 1935 as Styx State Fish Hatchery constructed by the Civilian Conservation Corps. In 1985 the facility was renamed the Cohen Campbell Hatchery in honor of a deceased manager.

As the hatchery is proximate only to Congaree Creek, the camp wasn't named "Styx" for its water source. It seems macabre, however, to have named the facility with the doughboys in mind.

As South Carolina is woefully lacking in notable caves -- this is a hydrologic fact -- perhaps the name was the state's grasp for subterranean territory. Further evidence of failed Carolinian subterranean claims may be found in Chapter 74, Railroads and Incrusted Lakes.



Ontario, Canada

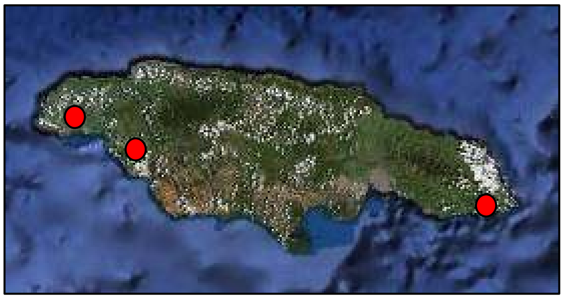
This River Styx is today a broad, shallow section of the Cataraqui River flooded for navigation.

Prince Edward Island, Canada

Between Muddy Creek and Union Corner

British Columbia, Canada

Summer discharge from Styx Glacier

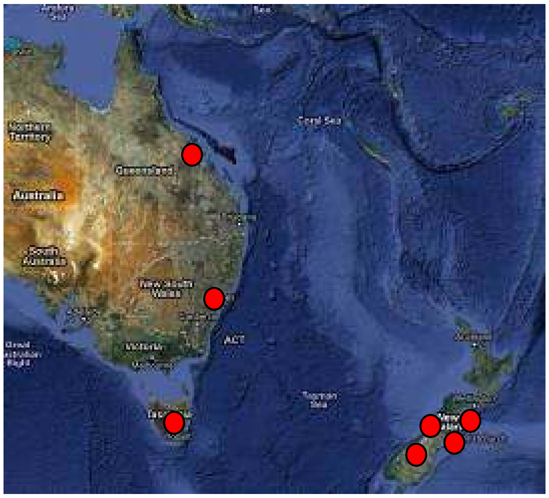


Jamaica

There are three Stygian rivers: at Westmoreland, St. Elizabeth and St. Thomas.

And Elsewhere

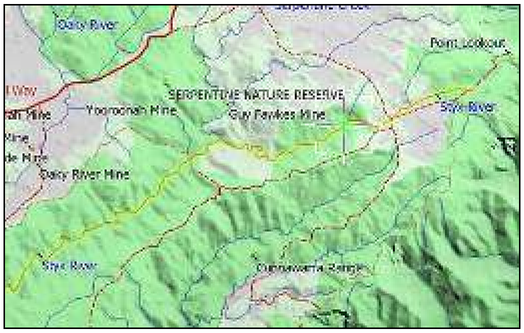
Australia and New Zealand add another seven.


Coral Sea
Northern Territory
Queensland
Australia
South Australia
New South Wales
ACT
Victoria
Tasman Sea

,

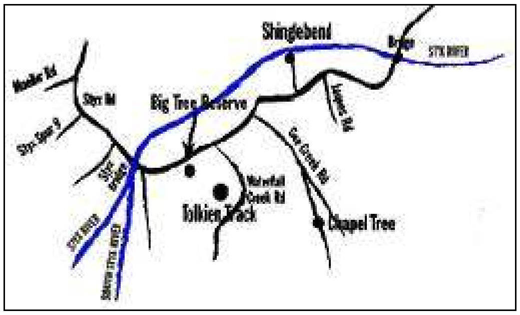
Queensland, Australia

This River Styx is a short channel in Charon Point Conservation Park which delivers significant sediment to Broad Sound. The wide mouth results in a 0.5-meter tidal bore and sharks are known to feed behind the advancing surge.


Oaky River
Point Lookout
SERPENTINE NATURE RESERVE
Yooroonah Mine
Guy Fawkes Mine
Styx River
Oaky River Mine
Styx River
Cunnawarra Range

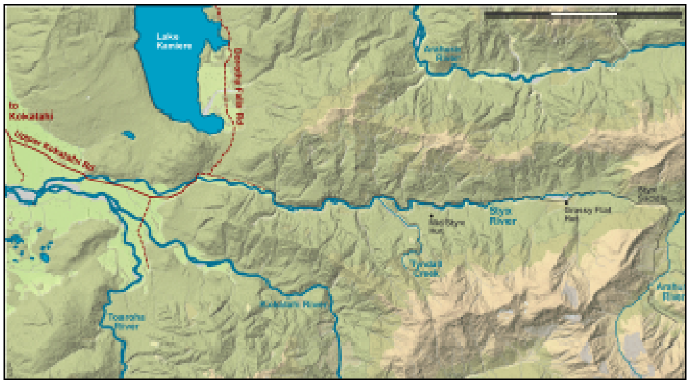
New South Wales, Australia

This River Styx rises in a spur of the Great Dividing Range and flows initially away from the coast through the Styx River National Forest


Shinglebend
Bridge
STYX RIVER
Mueller Rd
Styx Rd
Big Tree Reserve
Jones Rd
Styx Spur 9
Tolkien Track
Chapel Tree

Tasmania, Australia

The Styx Valley contains the tallest hardwood on earth, Eucalyptus regnans. Australia's most massive tree, "El Grande," discovered in 2002, was lost to a fire the following autumn.

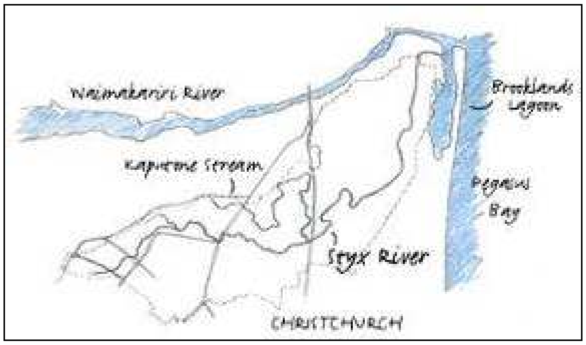

Lake Kaniere
Dorothy Falls Rd
to Kokatahi
Upper Kokatahi Rd
Arahura River
Styx River
Tyndall Creek
Kokatahi River
Toaroha River

Western District, New Zealand

This River Styx is noted for its fishing. The valley is bordered by the Tasman Sea to the west and the Southern Alps to the east.

Marlborough, New Zealand

This Styx flows into the Clarence River in New Zealand's northeast. Nearby, of course, is the River Acheron.


Waimakariri River
Brooklands Lagoon
Kapitone Stream
Pegasus Bay
Styx River
CHRISTCHURCH

Christchurch, New Zealand

In 1856, this Styx and its tributaries were surrounded by extensive wetlands and possibly flowed to the larger Waimakariri River. Today it's a suburban stream.

Otago, New Zealand

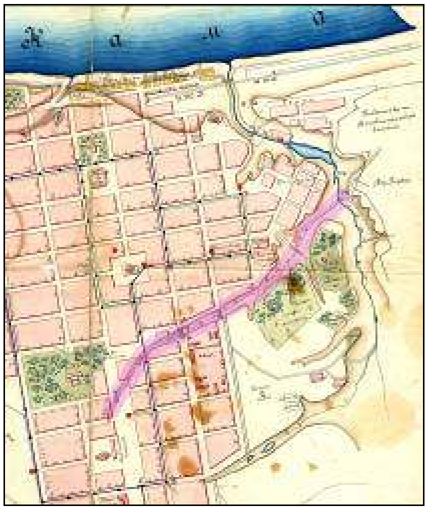
This River Styx was given its name because of its gold-rush-era service as a natural moat around the Paerau Prison. Today it is home to the extensive Taieri wetlands.

There are three versions of how the river near Christchurch received its name. In one, European settlers crossed the river on flax-stick rafts -- hence the name "Sticks." In a second version, the bundles of flax sticks were laid in the bed of the river. The third version suggests that flax sticks were stuck in the ground to guide travelers to a log bridge. In any case, the spelling was changed to "Styx" in the 1865-66 Register.

And still there are more.

Peak Cavern, Great Britain

The tumbling River Styx emerging from the cave mouth known as "The Devil's Arse," Chapter 51, The Tourist Trade Worldwide.

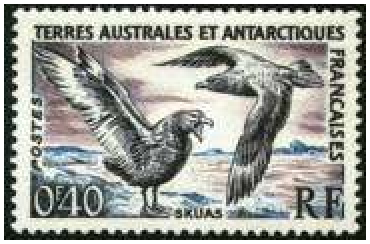


Perm, Russia, 1883

"Styx" in Russian is "Стикс."

New Caledonia

Styx Passage is not a river, per se, but a waterway of peril.



French Southern and Antarctic Lands

Le Styx is a stream in collection of volcanic islands having no permanent population, but issuing postage stamps.

A Neopolitan Discovery

We'll insert a relatively-recent discovery, not a surficial stream and thus technically outside of this chapter's surficial scope, but an informative example of how proper names can be cast about.

In the Footsteps of Orpheus: The Story of the Finding and Identification of the Lost Entrance to Hades, the Oracle of the Dead, the River Styx, and the Infernal Regions of the Greeks (1968) describes author Robert Paget's discovery of the classical River Styx on the shores of the Bay of Naples. That "this great archeological discovery by Robert Paget, formerly of the Royal Navy, and by Keith Jones of the United States Navy" lies counter to most academic opinion is of no consequence, we are assured, as

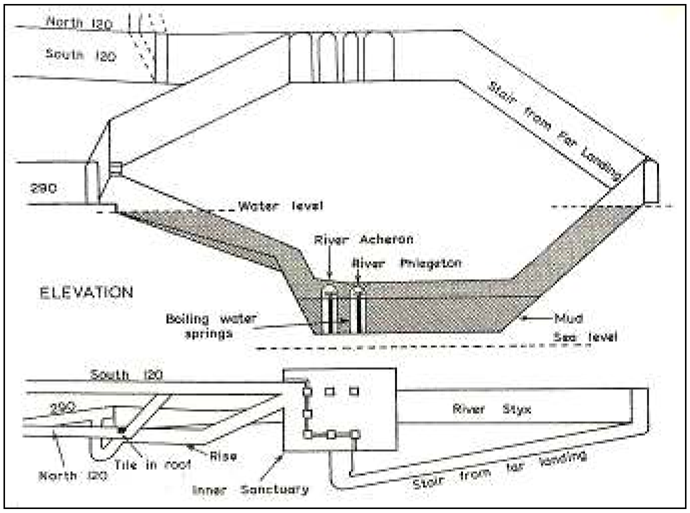
> *One of the great fascinations of archaeology, is that the evidence upon which many of the deductions are made is scrappy, to say the least of it. A piece of broken pot, a fragment of human cranium, the date on a coin -- ten professors will give ten different interpretations, and each swear that his is the only possible version. I have had quite an experience of this in the last five years, and I now have no hesitation in putting forward my own hypotheses, based upon scanty evidence, if they seem likely to provide a starting point from which to work. Most of the deductions in weighty volumes, derived from the fragmentary evidence of pre-history, are little better than intelligent guesswork, however much they may be wrapped up in learned jargon.*

With that surety, we'll summarize the discovery.

Circe's instruction to Odysseus were,

> *Beach your boat here by Ocean's swirling stream and march on into Hades' Kingdom of Decay. There the Flaming River and the River of Lamentation, which are branches of the River Styx, unite round a pinnacle of rock, to pour their thundering streams into Acheron. This is the spot, My Lord, that I bid you seek out.*

Odysseus does this, arriving at what Paget calls the "Great Atrium of the Oracle of the Dead." The ancient tunnels probed by the author were thought to be a relatively low-grade Italian antiquity, but according to his splunking, satisfy the significant specifications for the Great Atrium. Thus the water at the bottom must be the River Styx primeval.



"River Acheron" and "River Phlegeton" are author-assigned names for nothing more than thermal vents, respectful labels, we agree, but at the same time, further example of how honored names are transported.

The classical Styx was said to corrode all but a horse's hoof. That the water of today is good to drink apparently documents environmental improvement.

The Broader Question

And why, we must ask, are there so many Stygian rivers in broad daylight?

The answer seems to have little to do with subterranean origin, as only one of our survey -- the one in Britain -- is headed at a cave mouth.

The answer seems to have little to do with fluvial geomorphology, as our spectrum ranges from glaciers to bayous, cascades to meanders, bays to arroyos.

The answer may, however, relate to geochemistry. Consulting the Chapter 39 map of karst geology, 16 of the United States Stygian rivers are in or near karst terrain. The Ontario and British rivers are in limestone areas. Jamaica is basically a brick of carbonates. Although the Australian continent is only a few percent karst, none of its Stygian rivers are distant from karst landforms. New Zealand's South Island, on which all four Styx rivers of that nation lie, has notable karst. The river-namers would have been aware of regional geology and having been educated in an era when the classics were foundational, perhaps made connection to curricular folklore.

The answer in some cases derives from the toil of exploration. As the many of our rivers would have been inhospitable to exploration, some were named in frustration at best, in tragedy at worst.

As noted in Chapter 35, Underground Rivers in the Fine Arts, artists prefer a well-illuminated Styx. An accurately dark realm, we suppose, would be difficult to paint. As with the illustrators, our own imaginations -- and thus our namings -- pull the inky waters into visibility.

In lieu of descending into the darkness to meet Charon, we prefer him emerging in the noon-day sun.

CHAPTER 56

UNDERGROUND RIVERS ON POSTAGE STAMPS

We've already begun using vintage postcards as illustrations along our underground river journey and we will continue doing so. While a digital photo accurately conveys visual reality, even a grainy penny postcard has a social dimension. It's what travelers might have saved as a memento, what friends and relatives might have received in the mail, and in the larger sense, a snapshot of society's awareness.

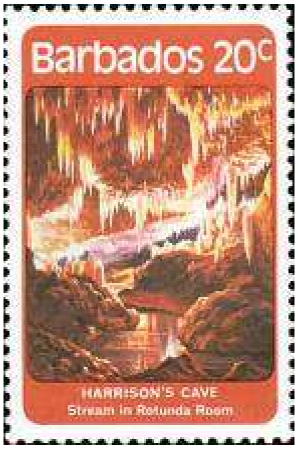
Postage stamps have somewhat the same quality. Hobbyists collect them over a lifetime, but for those who don't, who among us can't recall childhood awe at a stamp from a distant place and wonder about the wider world?

Postage stamps are today issued in such proliferation (roughly 10,000 issues/year, world wide) that serious collectors must specialize, most often by country or region. Other hobbyists build topical collections, one group being those who accumulate stamps with geological themes. Speleologists who are also stamp collectors are prone to favor stamps featuring caves, of which there are in the order of 160.

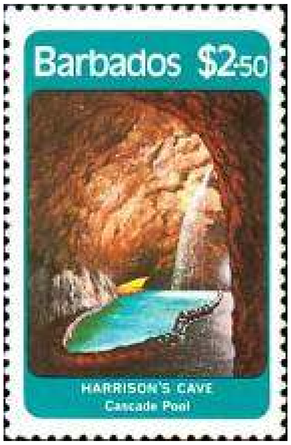
Our collection is yet more focused -- only postage stamps illustrating underground rivers. If we relaxed the criteria to that of caves which have underground waters, we might as well just do caves.

Here is our collection.

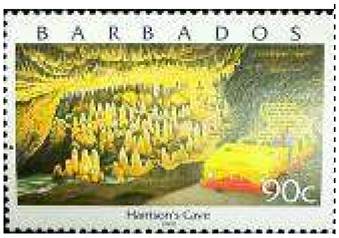
Barbados



1981
Harrison's Cave, Rotunda Room Stream

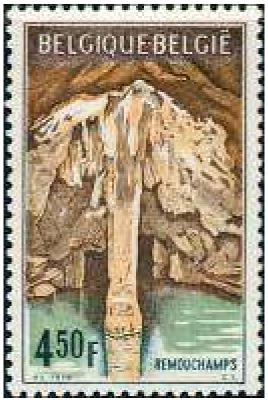


1981
Harrison's, Cave Cascade pool

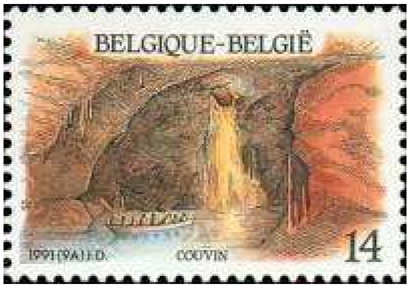


2000
Harrison's Cave. Travel by tram, but visitors are allowed to alight at certain points and approach the formations.

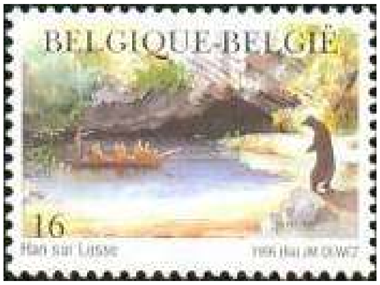
Belgium


BELGIQUE-BELGIË
4.50F
REMOUCHAMPS

1976
Remouchamps Cave's boat tour "glides mysteriously and without a sound over the winding subterranean river of almost 600 m in length."

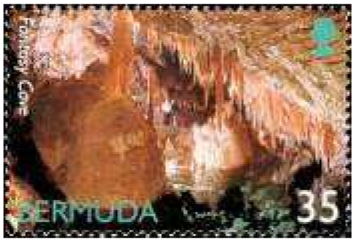

BELGIQUE-BELGIË
COUVIN
14

1991
Neptune Cave. The boat ride takes 20 minutes.

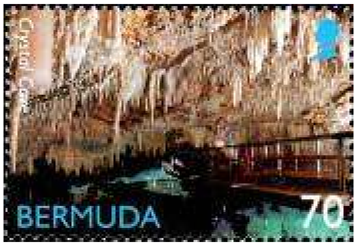

BELGIQUE-BELGIË
16
Han sur Lesse

1996
Han-sur-Lesse Cave. 3 stars in the Michelin guide. The tram's a century old. There's no bear.

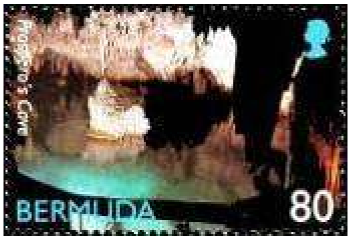
Bermuda


Fantasy Cave
BERMUDA
35

2002
Fantasy Cave links to…

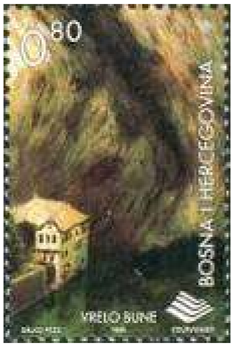

Crystal Cave
BERMUDA
70

2002
Crystal Cave. The cave floor can be seen 17 meters below the water surface.

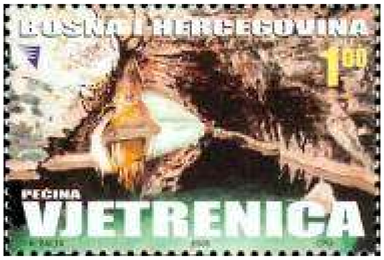

Prospero's Cave
BERMUDA
80

2002
Prospero's Cave contains an underground bar and discotheque.

Bosnia and Herzegovina

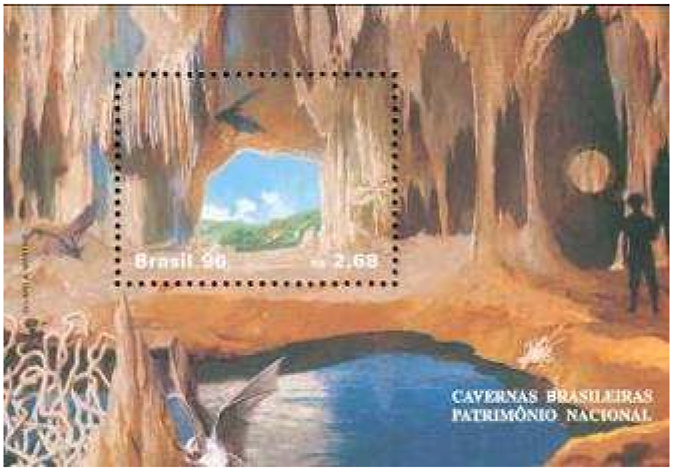

0,80
BOSNA I HERCEGOVINA
VRELO BUNE

1999
Buna Cave, the greatest European river springs, 30 cubic meters/second.


BOSNA I HERCEGOVINA
1,00
PEĆINA
VJETRENICA

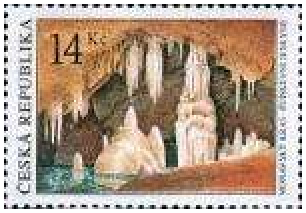
2008
Vjetrenica Cave (Chapter 72)

Brazil


Brasil 96
R$ 2,68
CAVERNAS BRASILEIRAS
PATRIMÔNIO NACIONAL

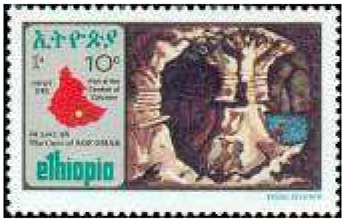
1996
Gruta do Lago Azul

Czech Republic


ČESKÁ REPUBLIKA
14 Kč

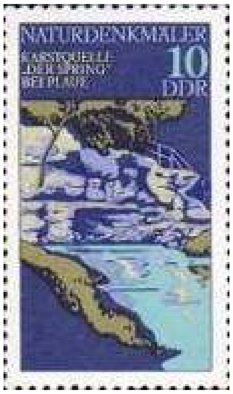
2003
Punkva Cave (Chapter 51)

Ethiopia


ethiopia
10c

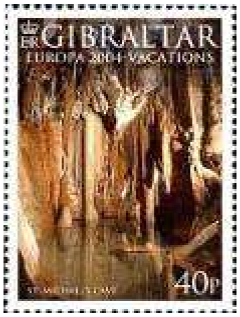
1983
Sof Omar Cave. A river rushes between narrow crevices.

East Germany


NATURDENKMÄLER
KARSTQUELLE „DER SPRING" BEI PLAUE
10
DDR

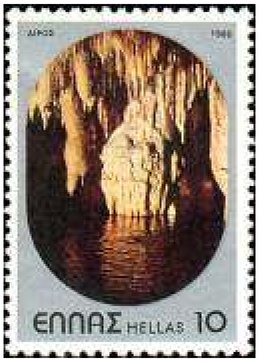
1977
Spring von Plaue, 0.6-0.8 cubic meters/second.

Gibraltar


GIBRALTAR
EUROPA 2004 VACATIONS
40p

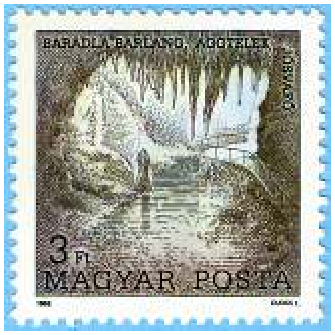
2003
St. Michael's Cave. As the Rock of Gibraltar was thought to be one of the legendary Pillars of Hercules, the Greeks believed this to be a Gate of Hades.

Greece

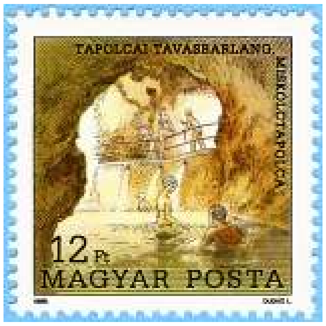

ΕΛΛΑΣ HELLAS 10

1980
Dyros Cave. *We entered the cave and to our surprise the thing we noticed first was the large cloud of smoke that was lingering about. The staff of ferrymen and assistants smoked in the cave and as the entrance is so small the smoke just lingered about the place... We were instructed to remain seated and not to extend our hands outside the boats as we began our journey through the cave propelled by the standing ferryman who used a long stick to push the boat along.* -- A recent tourist

Hungary

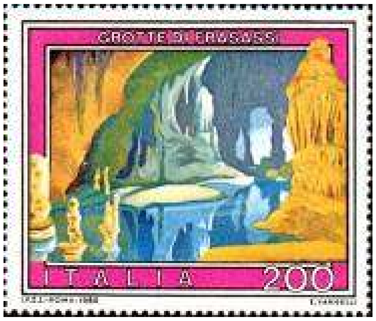

BARADLA BARLANG, AGGTELEK
3 Ft
MAGYAR POSTA

1989
Baradla Cave. Another River Styx (Chapter 55)


TAPOLCAI TAVASBARLANG
12 Ft
MAGYAR POSTA

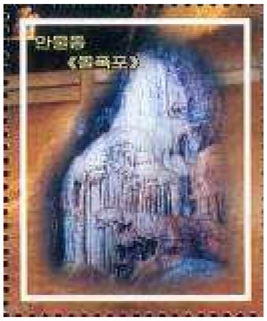
1989
Tapolcai Cave. The rim-stones of the cave pools were destroyed n 1938 to allow boating. A 25-meter tunnel was blasted to allow a round trip and the creek was dammed outside the cave to raise the water level within.

Italy


GROTTE DI FRASASSI
ITALIA 200

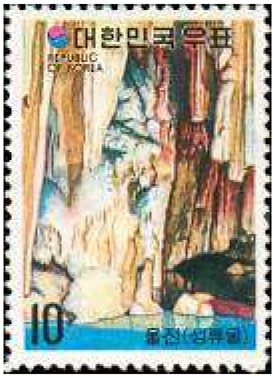
1982
Frasassi Cave

North Korea

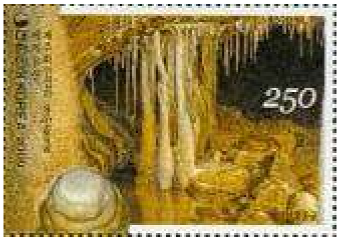


2002
Ryongmun Cave

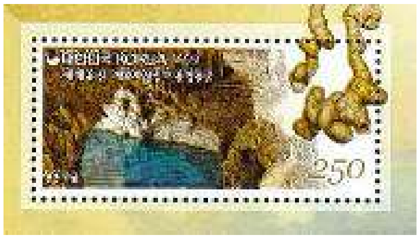
South Korea


대한민국우표
REPUBLIC OF KOREA
10

1973
Kusan-Ni Cave, noted for its pillars formed by stalactite and streams that flow between.

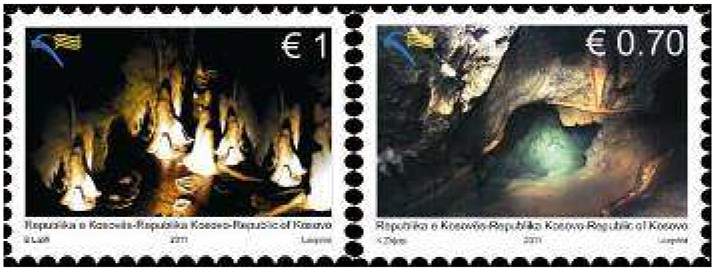


2009
Jeju Lava Tubes. World Natural Heritage, 2007



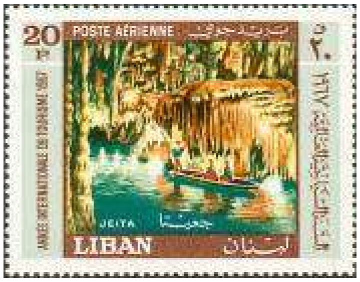
2009
Jeju Lava Tubes. Rare caves because despite being lava tube caves, they also display limestone formations.

Kosovo


€ 1
€ 0.70
Republika e Kosovës-Republika Kosovo-Republic of Kosovo
2011
Republika e Kosovës-Republika Kosovo-Republic of Kosovo
2011

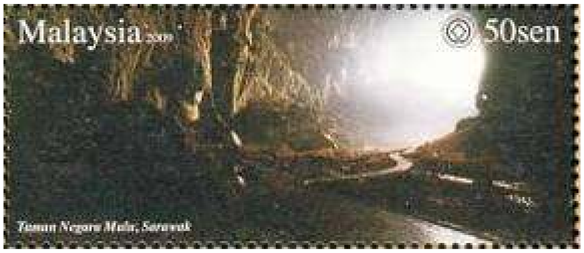
2011
Grand Canyon Cave in Peja

Lebanon


20
POSTE AÉRIENNE
JEITA
LIBAN

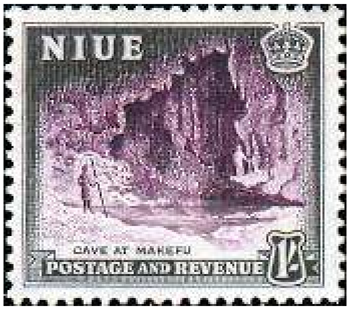
1967
Jeita Cave (Chapter 51)

Malaysia

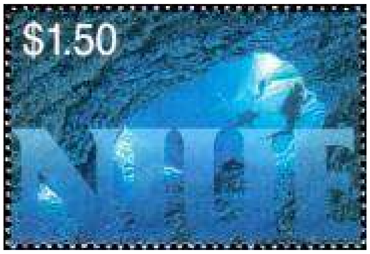

Malaysia 2009
50sen
Taman Negara Mulu, Sarawak

2009
Deer Cave contains the world's largest karst cavern, large enough to contain London's St. Paul Cathedral five times over and accommodate 40 Boeing 747s side by side.

Niue

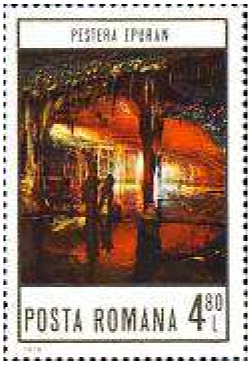

NIUE
CAVE AT MAKEFU
POSTAGE AND REVENUE
1/-

1950
Makefu Cave. Niue is a limestone block in the Pacific.



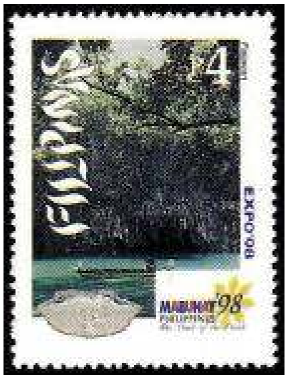
1998
Underwater cavern. Niue is best known for it postage stamps and coins.

Romania

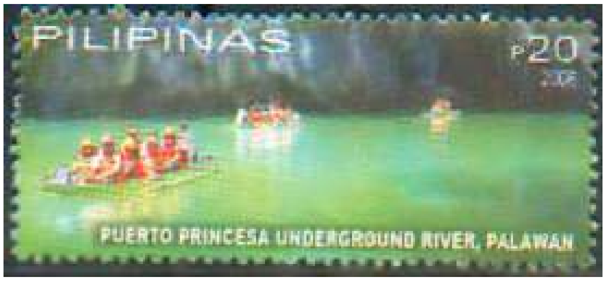

PESTERA EPURAN
POSTA ROMANA 4 80 L

1978
Epuran Cave

Plilippines

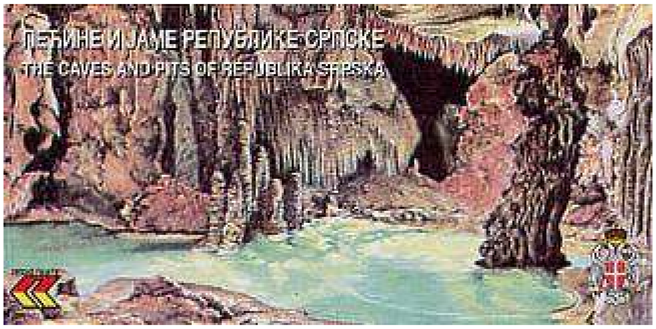

PILIPINAS
4
EXPO'98
MABUHAY'98

1998
Puerto Princesa


PILIPINAS
P20
PUERTO PRINCESA UNDERGROUND RIVER, PALAWAN

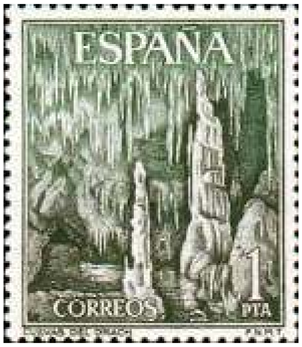
2008
Pureto Princesa

Serbia


ПЕЋИНЕ И ЈАМЕ РЕПУБЛИКЕ СРПСКЕ
THE CAVES AND PITS OF REPUBLIKA SRPSKA

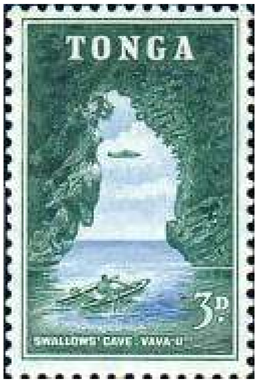
2001
Cover of stamp booklet. None of the six stamps, however, illustrate water features.

Spain


ESPAÑA
CORREOS
1 PTA

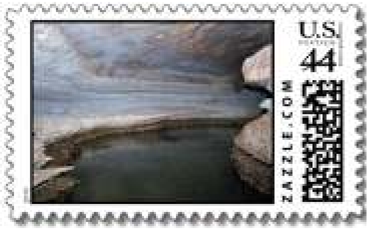
1964
Cueva del Drach (Chapter 49)

Tonga


TONGA
3D
SWALLOWS' CAVE · VAVA-U

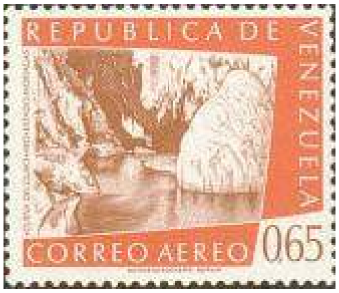
1953
Swallows Cave, a sea cave

United States


U.S.
44
ZAZZLE.COM

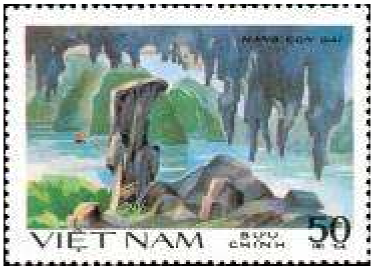
2010
Cave Habitat. Zazzle Inc., an approved licensed vendor of the U.S. Postal Service, prints valid postage stamps per customer design. Twenty 44-cent stamps cost from $20.60 to $23.15.

Venezuela

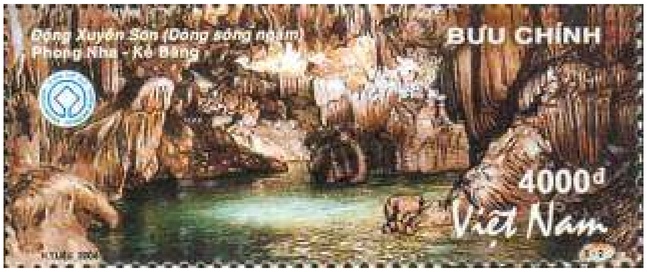

REPUBLICA DE VENEZUELA
CORREO AEREO
0,65

1960
Curea de Guacharo, Venezuela's first National Monument.

Viet Nam


VIỆT NAM
BƯU CHÍNH
50

1984
Hang Bo Nau Cave

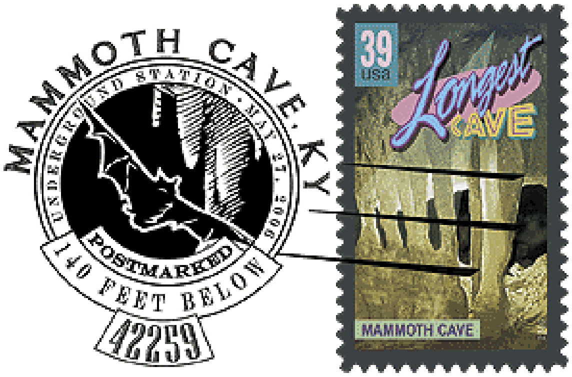

Động Xuyên Sơn (Động sông ngầm)
Phong Nha - Kẻ Bàng
BƯU CHÍNH
4000đ
Việt Nam

2006
Xuyen Son Cave

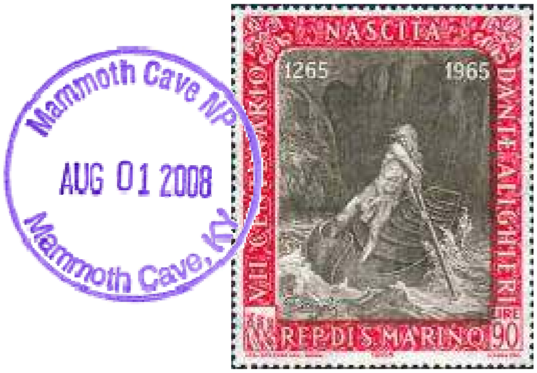
As noted in Chapter 52, The American Tourist Trade, the United States is historically prone to assert world records. We are thus disappointed with the scant American philatelic participation, a single underground river stamp, and even that being of a variety more often produced for wedding invitations. Why a nation that honors the Homer Simpson family with a set of five has issued but one commemorative for Mammoth Cave National Park, and that without the Echo River, we do not comprehend.

The best we can do is to take a stamp from a European nation of which few Americans (other than stamp collectors, that is) have ever heard, affix it to a Mammoth Cave postcard and post it riverside.

United States


MAMMOTH CAVE, KY
UNDERGROUND STATION MAY 27, 2006
POSTMARKED
140 FEET BELOW
42259
39 USA
Longest CAVE
MAMMOTH CAVE

San Marino


Mammoth Cave N/P
AUG 01 2008
Mammoth Cave, KY
NASCITA
1265
1965
DANTE ALIGHIERI
VII CENTENARIO
LIRE 90
REP. DI S. MARINO

2006 Mammoth Cave	1965 Doré's Charon (Chapter 6, Back to the Cross) on the River Styx (Chapter 55, A Superfluity of Surficial Stygian Streams)

While the blasé U.S. stamp was postmarked a mere 140 feet below, ours (as repeatedly noted on the postcards of Chapter 50, Then, Madam, You Should Go and See the Great Cave in Kentucky) would be mailed at minus 360.

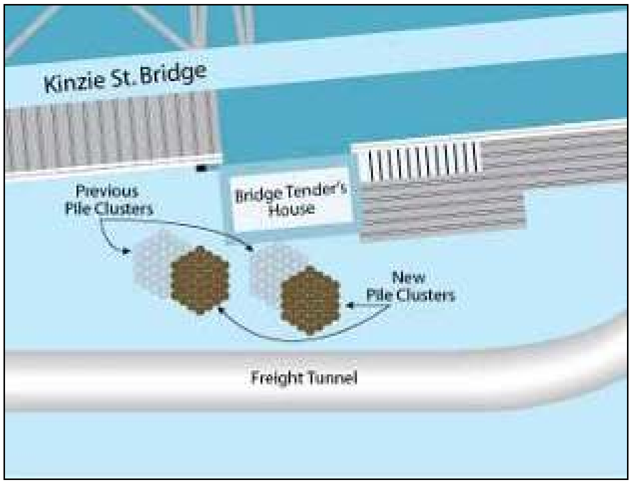
CHAPTER 57
CARGO CONVEYANCE

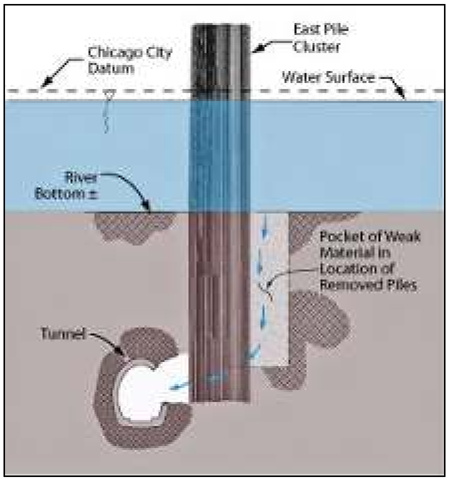
There's more to haul than vacationers, however. Here are some manifests of subterranean vessels of commerce.

Freight Tunnels

Learning as we go, as evidenced by "The Great Chicago Flood," Structure, August 2007, by Jon Wren,

> *In the early morning of April 13, 1992, dozens of downtown Chicago buildings started to mysteriously flood. Soon flooding knocked out utility services to more than 100 buildings. And the worst was yet to come. Flood water seeped into subway tunnels, shutting down the entire subway system. A major expressway inexplicably flooded, causing shutdown of several lanes of traffic. Hundreds of thousands of workers were sent home. Paralysis quickly gripped one of the nation's major economic centers. It took six days to plug the source of floodwater, and over a month and $5 million to dewater building basements. The cost of the flood would ultimately total approximately $1 billion.*
>
> *The original intent of the tunnel system was to carry telephone and telegraph wires and cables. A 1903 ordinance allowed tunnel operators to officially transport merchandise such as coal, and remove solid waste from connections to the basements of over 80 buildings. The tunnel was equipped with a 24-inch gauge track and electric trolleys to convey merchandise. As a point of reference, at its zenith in 1928, the rail system employed 580 workers and had in excess of 3,300 rail cars to handle over 660 tons of goods annually. By 1959, a lack of demand and funds to repair equipment caused the freight system to be functionally abandoned. Currently, the tunnel system houses power and fiber-optic cables.*
>
> *The source of the underground flood was the North Branch of the Chicago River, pouring into a breeched section of an abandoned freight tunnel crossing beneath the river at Kinzie Street. The tunnel was part of a 62 mile network of abandoned freight tunnels, originally built in the early 1900s, crisscrossing downtown Chicago and connecting to building basements.*
>
> *Six months before the flood, two dolphin pile clusters protecting the southeast abutment of the Kinzie Street Bridge were removed; the clusters were relocated approximately three feet to the south (unwittingly closer to the tunnel), and new piles were driven.*





> *The underground flood was caused by driving dolphin piles closer than planned to the freight tunnel resulting in a tunnel breach and eventual flooding of the tunnel system. The effects of*

> *the removal and driving of two dolphin pile clusters near the freight tunnel dramatically increased loading on the tunnel, and serve to explain the tunnel breach and subsequent flooding. Thus, Chicago's great underground flood provides many valuable lessons for engineers. For a recovered Chicago, the disaster is a distant memory and, as the old saying goes, "water under the bridge."*

Timber

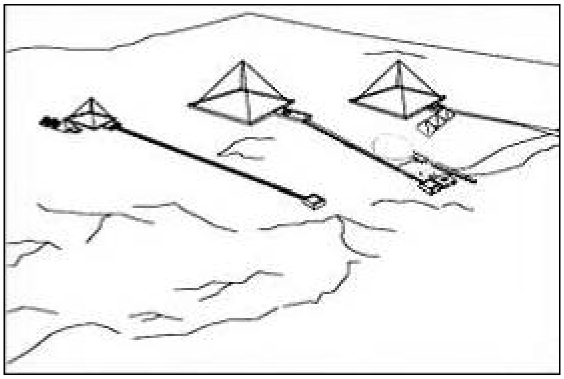
In the 1950s, Sunken Lake, on Michigan's Thunder Bay River disappeared when the lakebed sinkholes became unplugged. The lake reappeared the following year when the holes replugged with sediment. Legend claims that loggers would ride atop logs, only to disappear down the riverbed sinkholes and reappear 37 kilometers southeast at Lake Huron, still smoking their pipes.

World Record
Underground River
Tallest Tale

Mummies

Shafts that penetrate the Giza pyramids appear to the researchers at Earthmilk Ancient Energy to be part of an underground water system that once flowed into the pyramids.

Chamber under Sekhmekhet's pyramid



Approximate location of channels to Nile

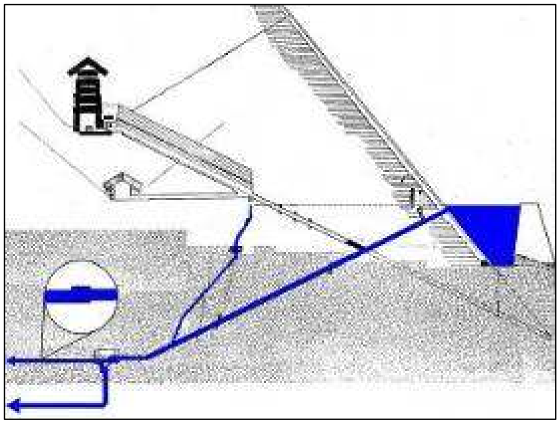
From Earthmilk Ancient Energy's internet posting,

> *There are also shafts in the bottom of the water yet to be explored. At one time in history, when the Nile flowed beside the pyramids, the opening here was deep under the surface of the river, and the enormous chamber would fill up with water, directly underneath the pyramids.*
>
> *I know that if those huge holes were filled with water, they could force water to flow through the small narrow horizontal passageways to the pyramids using simple water hydraulics and Bernoulli's principle of moving fluids.*

Earthmilk's hydraulic insight, however, appears not to include Bernoulli's principle, an energy balance which employs "moving" as an adjective, not as an active verb.

Tony Bushby, in "Lost History of the Pyramids -- The Underground Labyrinth of Egypt," Nexus Magazine, April-May 2004, offers another pyramid theory, one employing subterranean channels to pump water.

> *A Modified Hydraulic Ram Pump at Giza*
>
> *The pyramid had a tall masonry enclosure that was higher than the pyramid's entrance. Water was flooded between this masonry wall and the pyramid via tunnels from the ancient Lake Moeris. Lake Moeris and the Western Nile were at higher elevations and allowed for water tunnels to gravity feed to this pyramid's moat. One of the water tunnels existed as a "well" in front of the pyramid's entrance. This well has since been covered with pavement.*
>
> *As the moat filled, water flooded the entrance and ran down the descending passage into the subterranean chamber.*
>
> *The pump assembly incorporates the descending passage, subterranean chamber, the "dead end" shaft, the pit, the well shaft and grotto. To complete the basic hydraulic ram, two blocked tunnels need to be cleared. At the end of the "dead end" shaft exists a plane surface that correlates to the backside of a check-valve. The pit hasn't been completely cleared of rubble to expose the horizontal shaft, yet. In the running model the water in the well shaft pulsed at the grotto height even though this is below moat elevation.*
>
> *At the lower end of the descending passage a tunnel leads up towards the lowest of the two upper rooms. This shaft is known as the "well shaft." Until the late 1800's most of the descending passage, the lower part of the well shaft and the subterranean chamber had been buried for a thousand years. Indigenous teachings state emphatically that there is still a buried tunnel that leads from the bottom of the subterranean chamber's pit to the location of the ancient Nile River.*
>
> *This tunnel was a drain that had a mechanical element at its end. This mechanical element is possibly a sliding stone plug, which opened and closed causing a pulsing action. The "dead end" shaft terminates 57' past its entrance. It is my hypothesis that the termination is the back face of a closed check valve, and a tunnel exists beyond.*
>
> *To maintain consistent pulse timing, the pyramid's moat requires a specific static level. To ensure this, the moat is provided more water than is consumed.*



> *The excess water was removed by the causeway running down to the Nile River.*

The pyramid's moat is another secret, but not to those of us with access to the Internet.

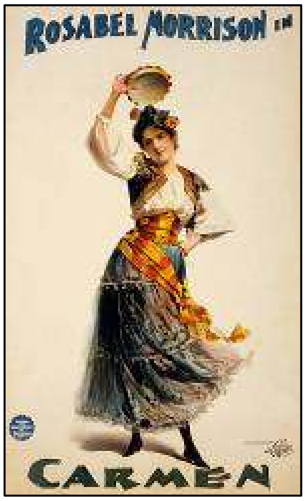
Loot

When an underground river is dry and cargo must be transported, there may yet be a war.

The rogues in The Italian Job (1969) transferred their loot to BMC Minis and escaped through the Milan sewers.

Tobacco

Seville's Royal Tobacco Factory, built in the 1700s employed 800 women, Georges Bizet's Carmen (1875) being today the most famous.



Carmen at the Met
$384.00 to $728.00

> *The building is still surrounded on three sides by a deep ditch or moat, whose damp floor is smothered in greenery. And it still has its little guardhouses at each corner... The concierge in his cubbyhole told me there was a hidden embarcadero, a mooring point for boats that could travel via an underground river to and from the Torre del Oro just a few yards down the road towards the banks of the Guadalquivir. He said the secret waterway was once used to bring tobacco in from galleons moored in the river, to prevent the precious cargo being seized by pirates before it reached its destination. He added that the entrance to this underground rivulet was "in the gardens" and "infested by cockroaches." I could not find it, but perhaps it exists, clogged by undergrowth. However, a couple of prints of the sixteenth-century city that I bought nearby clearly show a rivulet winding inland beside the Torre del Oro. It was the Tagarete, a tributary that meandered into the Guadalquivir in this marshy city. The waterway disappears from the maps in the early 1700s, when the factory was built.* -- Elizabeth Nash, Seville, Córdoba, and Granada, a Cultural History (2005)

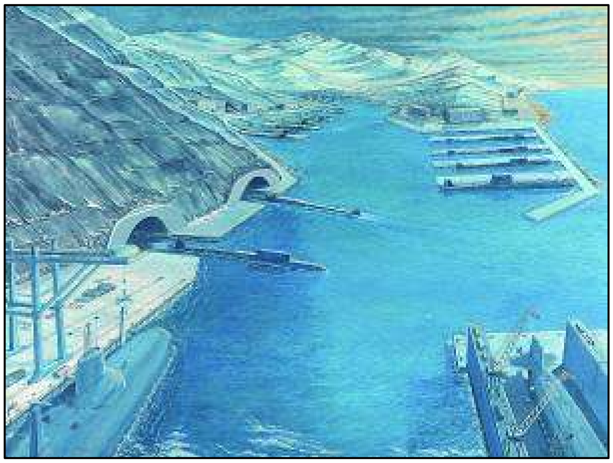
The maps below show the period factory site and its restoration. The hidden-from-pirate-eyes Tagarete is now the fashionable Calle San Fernando.

Alcazar
Real Fábrica de Tabacos

Warheads

Soviet Typhoon and Delta IV-class strategic ballistic missile submarines deployed in the 1980s from tunnel bases.

The drawing "Soviet Ballistic Missile Submarine Base" (1986) by Brian W. McMullin portrays how such facilities were envisioned.



Since the dissolution of the USSR in 1991, several of these bases have been opened to the public.

The Balaklava Underground Submarine Base, Sevastopol, Ukraine was built in the late 1950s for repair and equipping of Soviet submarines. Having a 600-meter tunnel to the sea, the plant was designed to withstand a 100-kiloton nuclear strike. The tunnel diameter is as much as 22 meters, of which 8.5 are submerged. The entrance was disguised such that a spy would not recognize it, though of course the United States wasn't relying on agents posing as fishermen.

The last submarine left in 1995 and the defunct facility now welcomes tourists.

Balaklava
$2.00

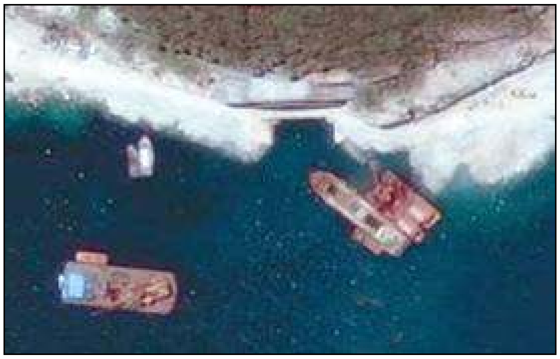
The former Yugoslavia was also a location of submarine bases. Below are two in present-day Croatia.

Vis Island Submarine Base

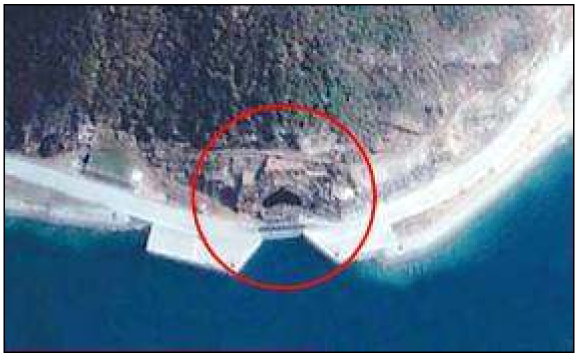
Dugi Island Submarine Base

The Dugi facility is was 7 meters deep, some 200 meters long, 30 meters wide and 20 meters high.

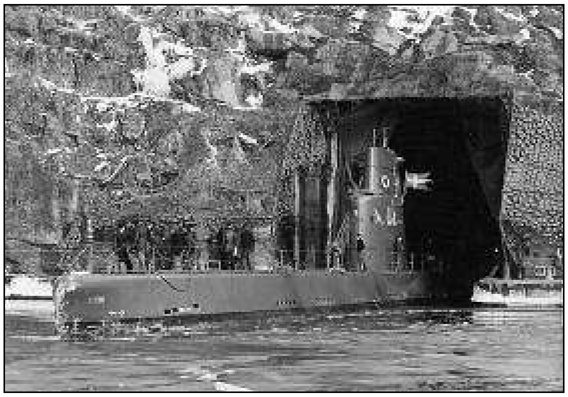
The satellite images of China's Hainan Island reveal a tunnel entrances thought to lead to caverns capable of hiding up to 20 nuclear submarines. A 094 nuclear submarine capable of carrying twelve nuclear warheads has been observed moored at an adjacent jetty.



Excavation Barges, 2005

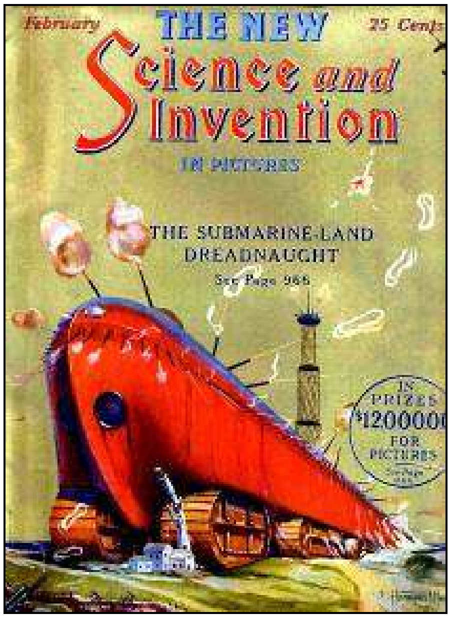


Completed Tunnel Entrance

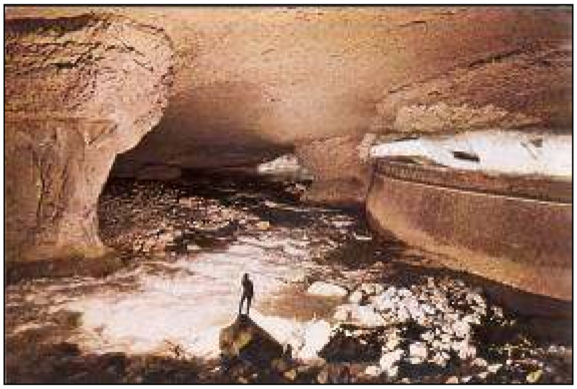


Above, the gate to Sweden's underground Muskö naval facility

And to the right, who says that a submarine can't also navigate on land? "A Submarine-Land Dreadnaught", Science & Invention, February 1924, portrays a 250-meter tall war machine that could sneak up a correspondingly-deep underground river to an enemy's capital


February
THE NEW
25 Cents
Science and Invention
IN PICTURES
THE SUBMARINE-LAND DREADNAUGHT
See Page 966
IN PRIZES
$1200000
FOR PICTURES

Highways



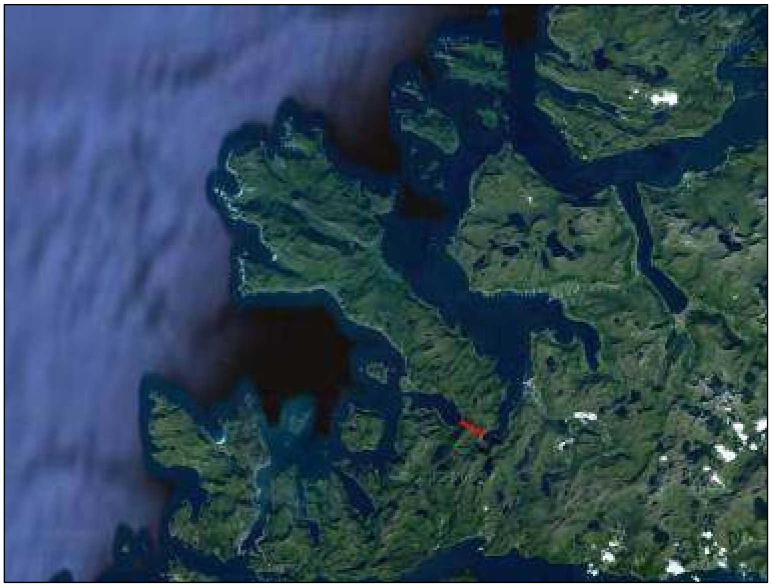
Mas d' Azil Cave in the Pyrenees. In lieu of a costly motor route around the limestone ridge, French road-builders followed the river through it.

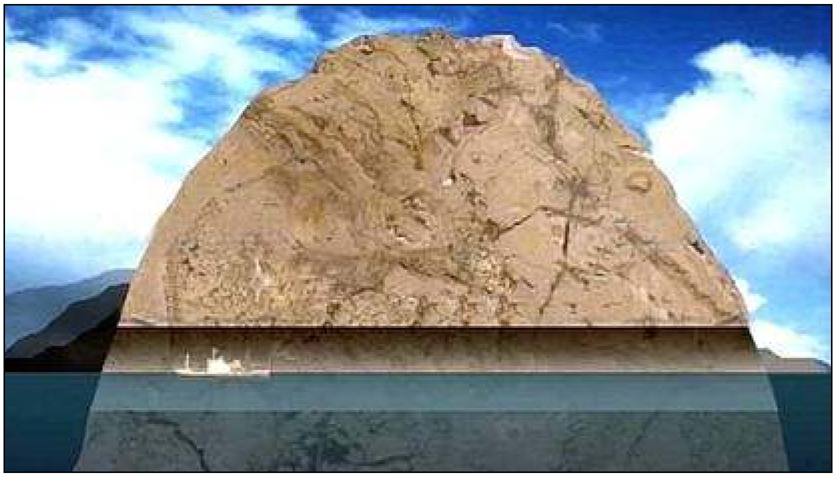
Tour de France, 2006, Stage 12

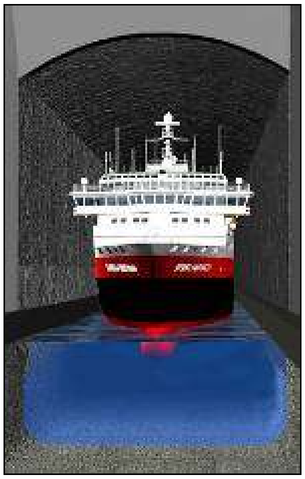
Stad Skipstunnel

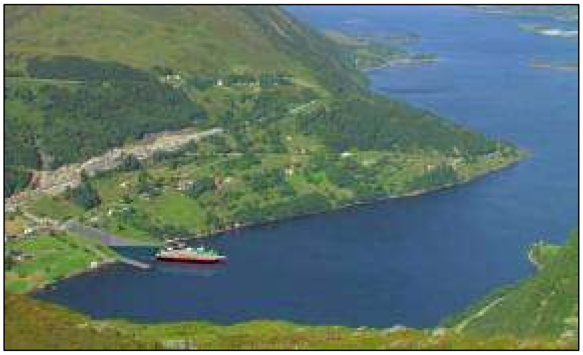
The combination of ocean currents and submarine topography creates complex and unpredictable wave conditions on the western coast of Norway, causing long delays while ships wait for calmer conditions.

The Stad shipping tunnel was proposed in 2007, a 36 meter wide by 49 meter high rock tunnel with a 12 meter draft, enough to allow ocean-going ships to cut through the 1,800 meter isthmus north of Bergen.









Conceptual entrance

A 2011 report to the Norwegian Coastal Administration, however, concluded that a tunnel would cost between NOK 1,300 and 2,000 million. Benefits, largely the reduced waiting costs, have a present value between NOK 300 and 400 million, insufficient to justify the investment.

There's money to be made in subterranean shipping, but perhaps not in Norway.

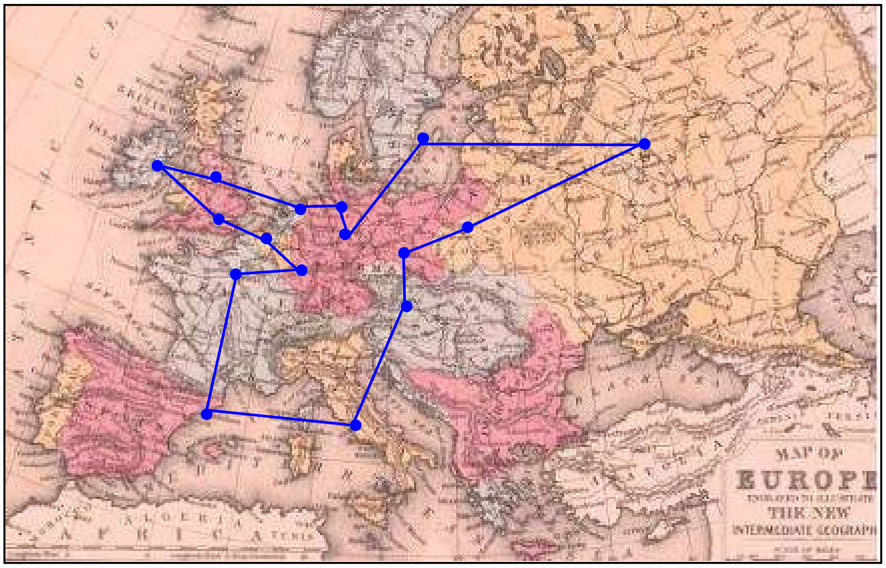
CHAPTER 58

THE GRAND TOUR, EUROPEAN SEWERS OF DISTINCTION

What became known as the Grand Tour began as a right of passage in which young upper-class European men of the 17th-century enjoyed an adventurous jaunt about the continent before settling into their staid professions. By the 18th century, a more-gentile Grand Tour provided wealthy American families opportunity to refine language skills, imbibe the cream of European culture and perhaps most of all, associate with the right foreigners.

We'll undertake our own Grand Tour, but ours to be a tour of Europe's more notable underground rivers of sewage. In deference to our topic's rich history, we'll plot our circuit on an 1875 European map.

Sixteen cities, 16 sewers! Plus we'll catch some movies.



A key to understanding the rivers we're to visit cam be found in the Lord Peter Wimsey mystery Thrones, Dominations (1998) begun in 1936 by Dorothy L. Sayers and completed by Jill Walsh. The title comes from Milton's Paradise Lost, a foundational English work about underground rivers (Chapter 16, Underground Rivers in English Fiction).

> *You can bury them deep under, sir; you can bind them in tunnels... but in the end where a river has been, a river will always be.*

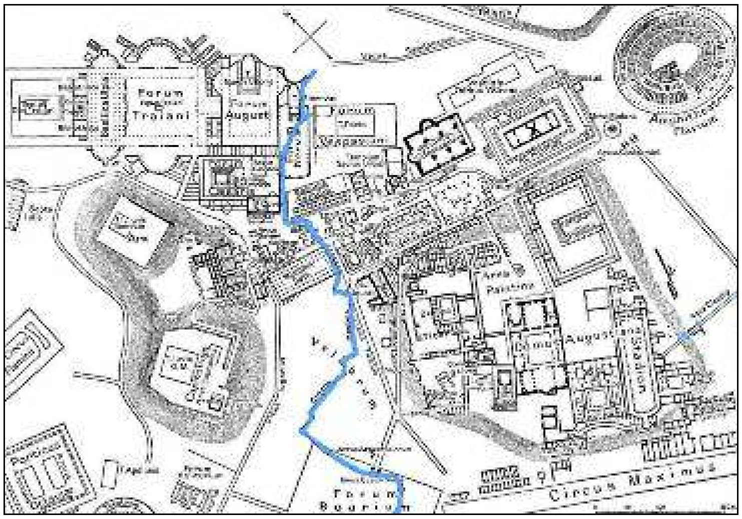
Every buried river on out Grand Tour was long ago a sunlit stream.

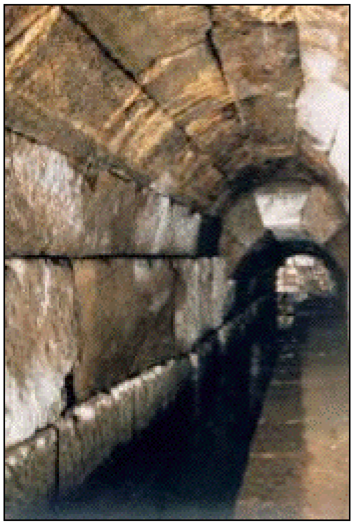
Rome

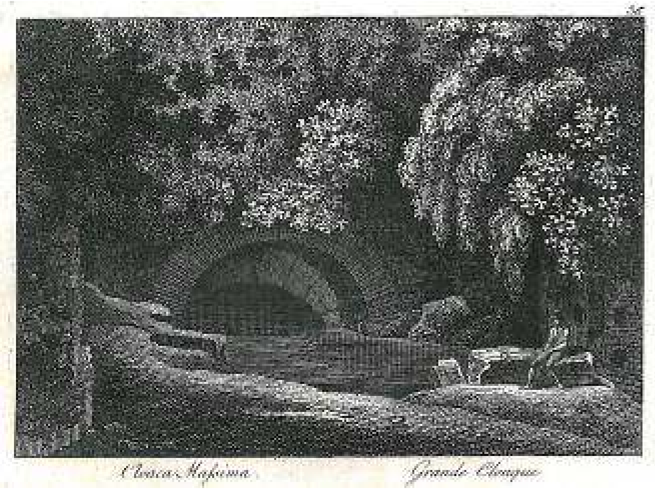
Our tour begins with the grandparent of modern sewerage, Rome's Cloacae Maxima, a canal in the sixth century BC and covered four centuries later. From Pliny's National History (c. 77 AD),

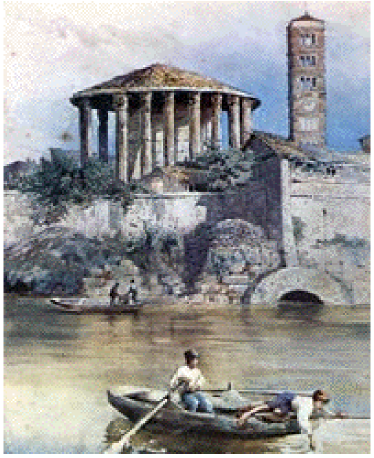
> *Hills were tunneled into the course of the construction of the sewers, and Rome was a "city on stilts" beneath which men sailed when Marcus Agrippa was aedile* [the Roman official in charge of public buildings]. *Seven rivers join together and rush headlong through Rome, and, like torrents, they necessarily sweep away everything in their path. With raging force, owing to the additional amount of rainwater, they shake the bottom and sides of the sewers.*
>
> *Sometimes water from the Tiber flows backwards and makes its way up the sewers. Then the powerful flood-waters clash head-on in the confined space, but the unyielding structure holds firm. Huge blocks of stone are dragged across the surface above the tunnels; buildings collapse of their own accord or come crashing down because of fire; earth tremors shake the ground - but still, for seven hundred years from the time of Tarquinius Priscus, the sewers have survived almost completely intact.*

The Cloacae Maxima yet flows under the Forum, joining the Tiber at Ponte Palatino, though no more a significant component of Rome's sewerage system.


Forum Traiani
Forum Augusti
Amphitheatrum Flavium
Area Palatina
Stadium
Circus Maximus
Forum Boarium




Cloaca Maxima
Grande Cloaque



"Sbocca della Cloaca Massima,"
E. Roesler Franz

Two 19th-century views

Roma (1972), directed by Federico Fellini, uses Rome's subterranean environs as a virtually plotless analogy of the human mind. Under modern tunnels filled with dripping pipes and laboring machines lie ancient catacombs leading to the underground river.

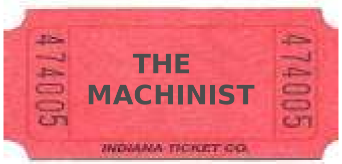
MMVII
ROMA
002007

Barcelona

The Museu del Clavegueram is our stop, where maps, plans and photographs explain the history of the city's wastewater system.

Museu del Clavegueram free

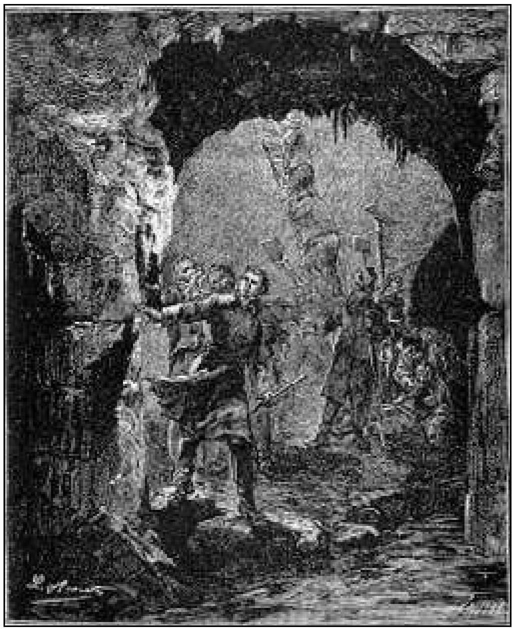
For an actual view of the Barcelona sewer, it's easier to watch actor Christian Bale wade through the gloom in The Machinist (2004).

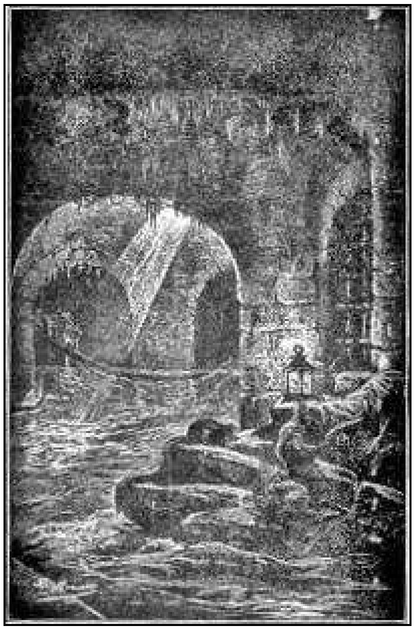


Paris

Subterranean sewerage began in 1370 from the Rue Montmartre to a tributary of the Seine. The system expanded over the next four centuries and in the early 1800s was reconstructed to add another 300 kilometers. By 1878, the system encompassed 580 kilometers.

It took Victor Hugo, however, to make Parisian sewers known to the world. Jean Valjean, the hero of Les Miserables (1862), steals a loaf of bread and is sentenced to forced labor. He escapes, becomes an industrialist and the King appoints him Mayor, but after arousing the suspicion of Javert, the police inspector, Valjean is sent to the galleys. He again escapes and hides in the Paris sewers on the eve of the 1830 revolution.





We don't need the the revolutionary plot, however, to sense the reality of the sewers.

> *It was a formidable campaign; a nocturnal battle against pestilence and suffocation. It was, at the same time, a voyage of discovery. One of the survivors of this expedition, an intelligent workingman, who was very young at the time, related curious details with regard to it, several years ago, which Bruneseau thought himself obliged to omit in his report to the prefect of police, as unworthy of official style. The processes of disinfection were, at that epoch,*

> *extremely rudimentary. Hardly had Bruneseau crossed the first articulations of that subterranean network, when eight laborers out of the twenty refused to go any further.*
>
> *The operation was complicated; the visit entailed the necessity of cleaning; hence it was necessary to cleanse and at the same time, to proceed; to note the entrances of water, to count the gratings and the vents, to lay out in detail the branches, to indicate the currents at the point where they parted, to define the respective bounds of the divers basins, to sound the small sewers grafted on the principal sewer, to measure the height under the key-stone of each drain, and the width, at the spring of the vaults as well as at the bottom, in order to determine the arrangements with regard to the level of each water-entrance, either of the bottom of the arch, or on the soil of the street. They advanced with toil. The lanterns pined away in the foul atmosphere. From time to time, a fainting sewerman was carried out. At certain points, there were precipices. The soil had given away, the pavement had crumbled, the sewer had changed into a bottomless well; they found nothing solid; a man disappeared suddenly; they had great difficulty in getting him out again. On the advice of Fourcroy, they lighted large cages filled with tow steeped in resin, from time to time, in spots which had been sufficiently disinfected. In some places, the wall was covered with misshapen fungi, -- one would have said tumors; the very stone seemed diseased within this unbreathable atmosphere...*
>
> *Tortuous, cracked, unpaved, full of fissures, intersected by gullies, jolted by eccentric elbows, mounting and descending illogically, fetid, wild, fierce, submerged in obscurity, with cicatrices on its pavements and scars on its walls, terrible, -- such was, retrospectively viewed, the antique sewer of Paris. Ramifications in every direction, crossings, of trenches, branches, goose-feet, stars, as in military mines, coecum, blind alleys, vaults lined with saltpeter, pestiferous pools, scabby sweats, on the walls, drops dripping from the ceilings, darkness; nothing could equal the horror of this old, waste crypt, the digestive apparatus of Babylon, a cavern, ditch, gulf pierced with streets, a titanic mole-burrow, where the mind seems to behold that enormous blind mole, the past, prowling through the shadows, in the filth which has been splendor.*

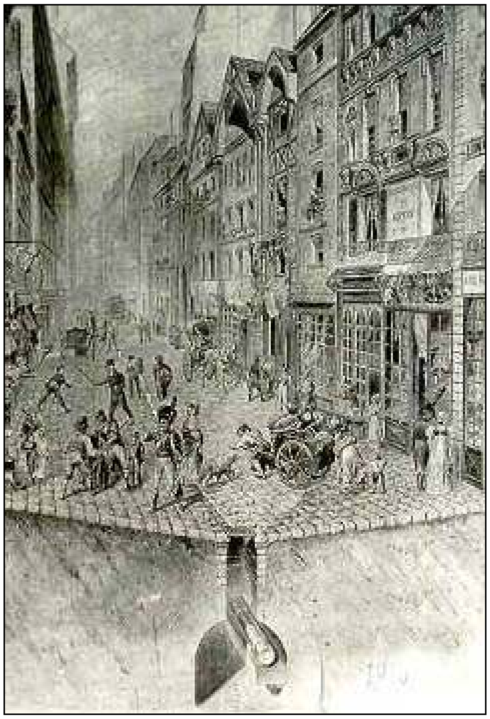
157010
Les Miserables
157010

Parisian sewer tours began in 1867 with white-suited sewer workers guiding visitors aboard special tour barges and wagons. Such excursions wouldn't have been unduly unpleasant, as the underground waterway was for storm runoff alone. Toilet waste wasn't to come until 1894. The rides, however, were to continue for another 80 years

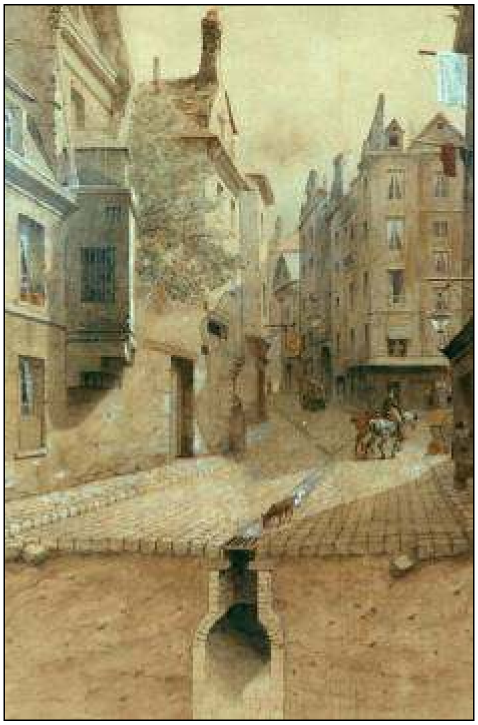
If Les Miserables didn't bring enough fame to the City of Light's underground rivers, The Phantom of the Opera (1910, Chapter 24, Underground Rivers in the Fine Arts) was soon to follow.

98642070
Phantom of the Opera
98642070

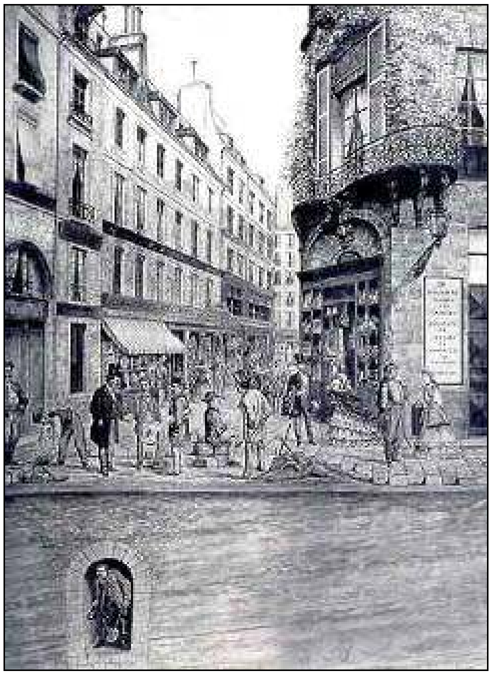
We've a rich history of illustration.



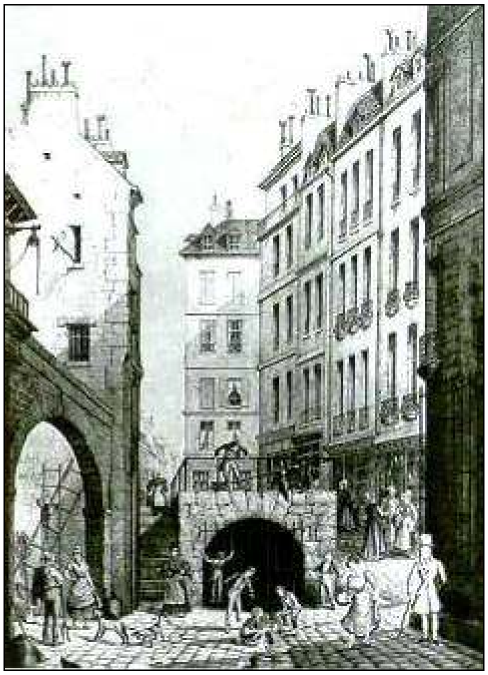
Égout de la Rue Saint-Senis, 1810



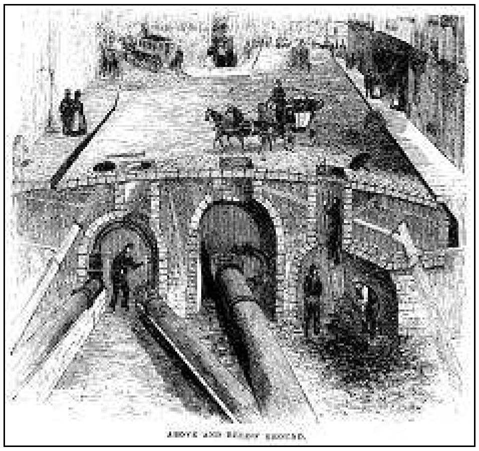
1820



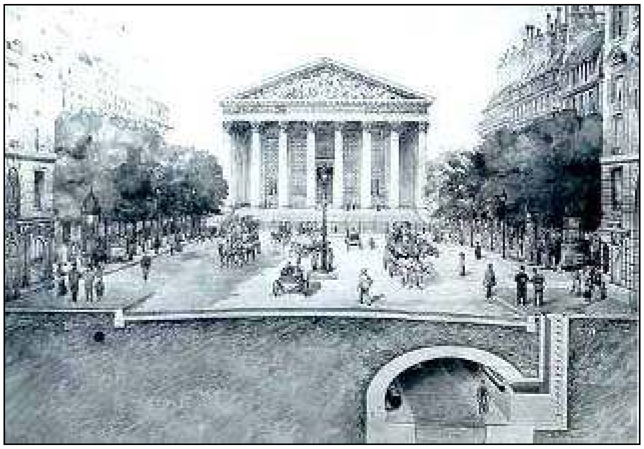
Égout de la Rue Thévenat, 1830



Égout Saint Benoit. Rue de l'Égout Saint Germain, 1840

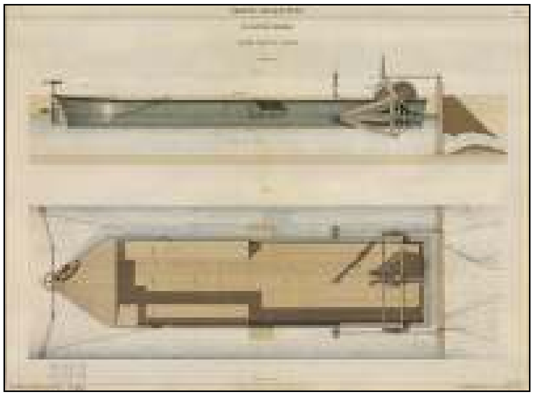

ABOVE AND BELOW GROUND.

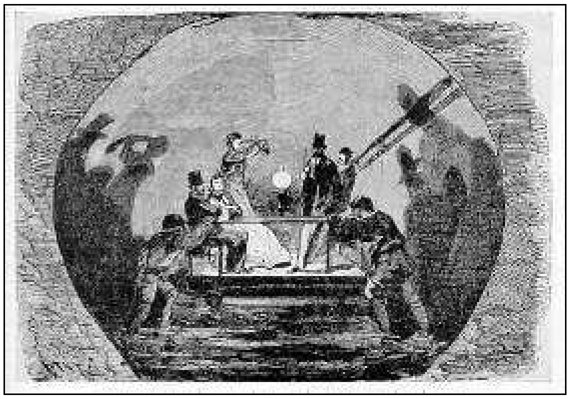
"Life in Paris - Sketches Above and Below Ground," Harper's New Monthly Magazine, February 1854

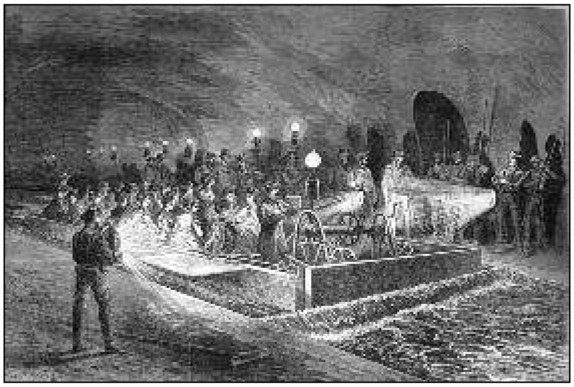


Égout de la Rue Royale, 1858

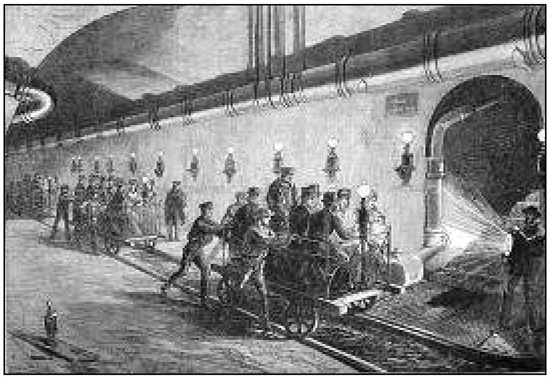
Paris sewers opened for tourism during the World Exposition of 1867, the tour boats piloted by uniformed sewer sewermen.



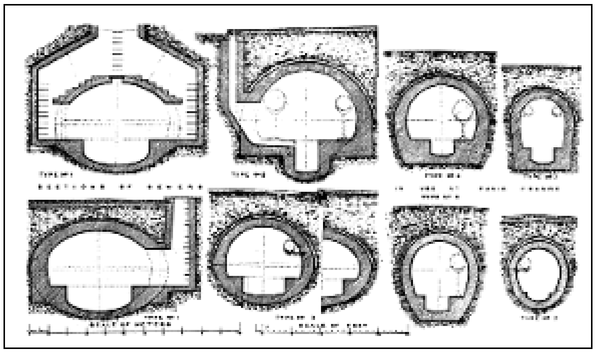




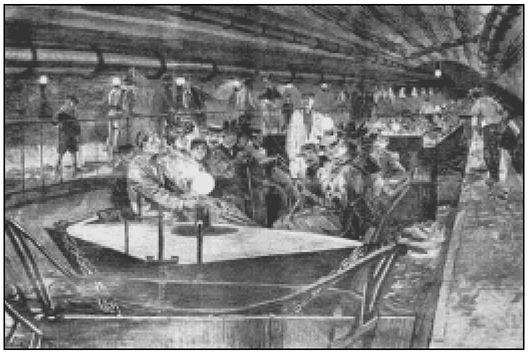
Tour by Boat, c. 1870



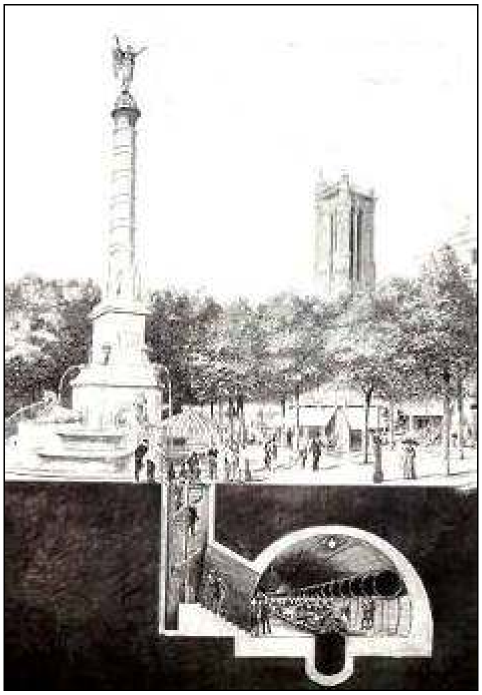
Tour by Rail



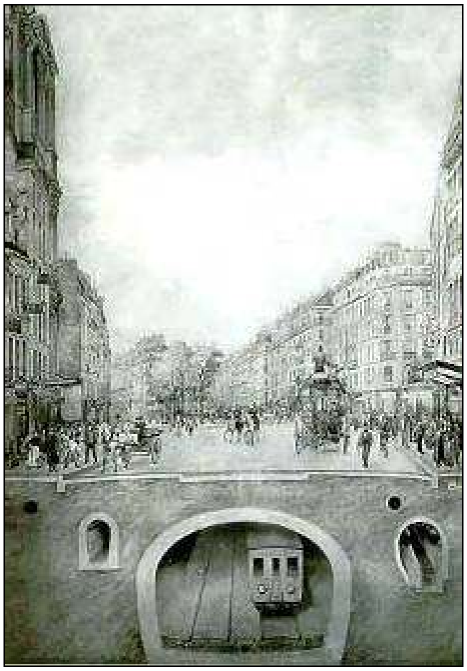
1884 Cross-sections



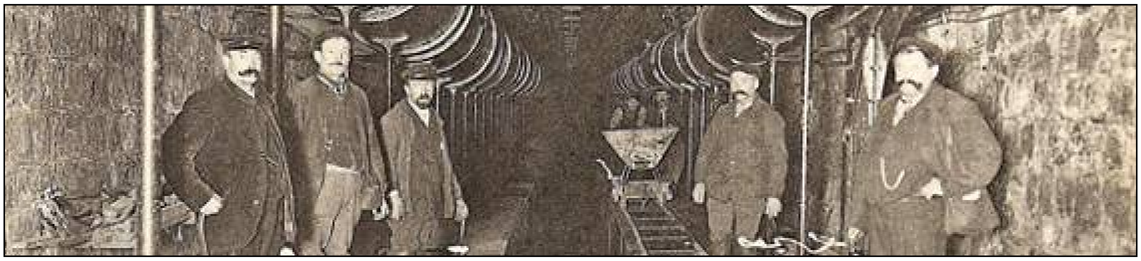
1896 Boat Tour



Entrée Place du Châtelet, 1892



Chemin de Fer Métropolitain, Égout Collecteur
Rue Saint-Antoine, 1914



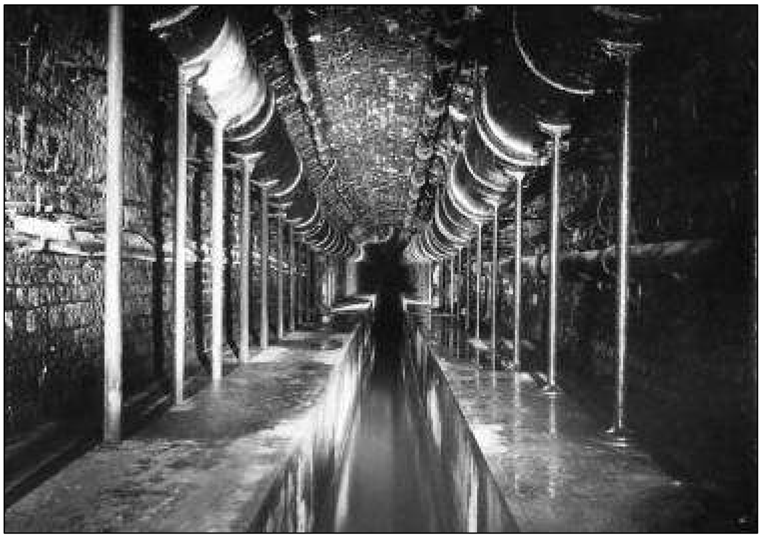
Workers with sewer cleaning equipment, c. 1930

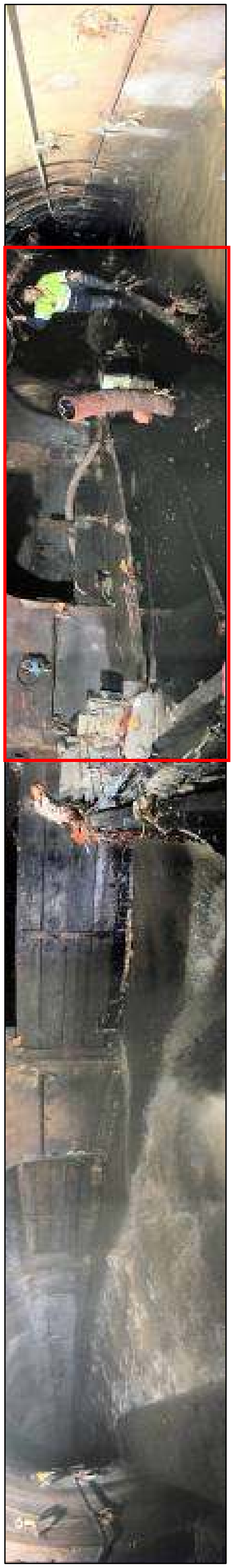
Modern Égoutiers

While in Paris, of course, we must attend to our répertoire culturel.

Felix Nadar spent three months of 1865 photographing Parisian sewers with lamps of his own invention to illuminate the 18-minute exposures. The stark images further enhanced the mystery of the eerie waterworks.

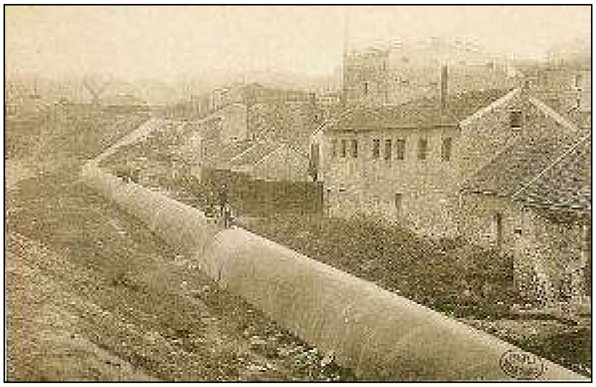
To German critic Walter Benjamin, this was "the first time that the lens is given the task of making discoveries."



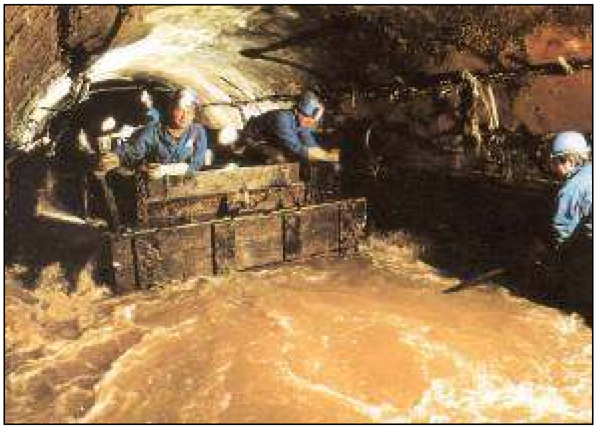


Shipwreck on the River Bievre.

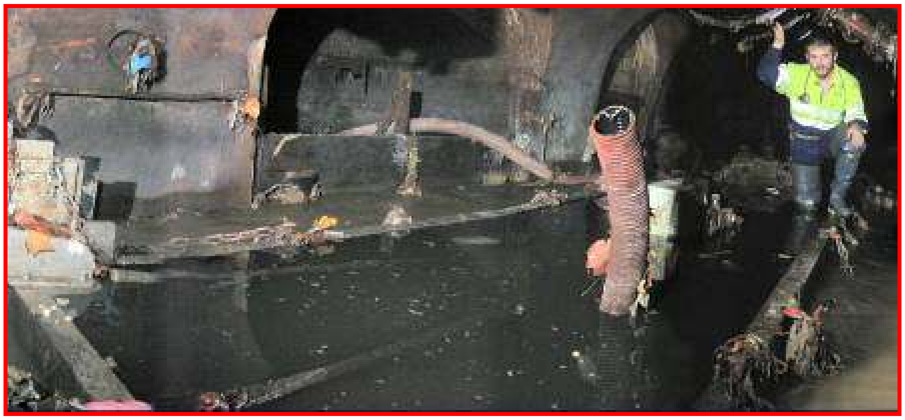
The River Bievre once flowed into the Seine in Paris, but in 1912 was converted into a collector sewer. In construction, 1910



Hydraulic barge used for sewer maintenance, 1978.



To the right, a panoramic photo of such a craft sunk in the Bievre in 2004



For modern tourists, more than 100,000 per annum, is the Musée des Égouts in the city's historic tunnels.

One display celebrates notable items retrieved, including swords, stolen handbags and false teeth. Another commemorates Eleanor, an 80 centimeter alligator caught by workers in 1984 and dispatched to a Paris zoo. We'll learn more about such urban reptiles in Chapter 82, Alligators Below.

VISITE
DES ÉGOUTS DE PARIS

Musée des Égouts de Paris €4.30

Trier, Germany

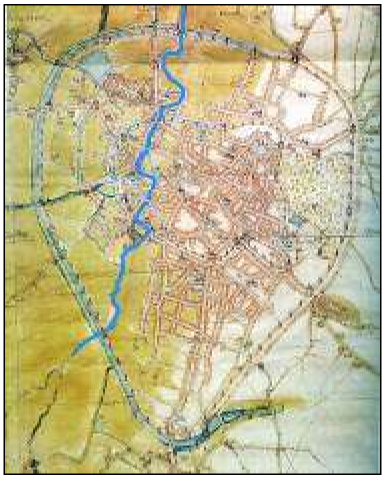
The Kaiserthermen (Emperor's Baths) of the fourth-century capital of the Western Roman Empire are now the gloomy remnants of the Imperial sewer network.

Kaiserthermen €11.50

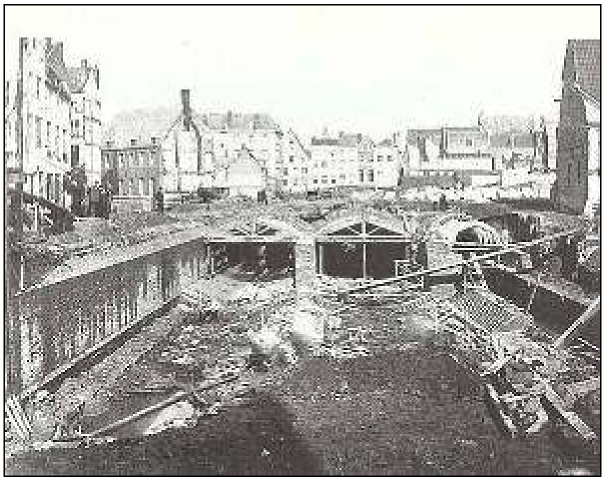
Sewer-arching Roman brickwork.

Brussels

By the late 18th century, Brussels' River Senne had lost its value as a navigable waterway and was replaced by canals. In times of heavy runoff, however, the sluice gates were unable to regulate the flow, inundating the working class neighborhoods along the lower banks. By the mid 19th century, garbage and decaying matter made the drainage a health hazard.



The Senne, 1550.



Covering the Senne, c. 1870

Covering the river began in 1867. The system consisted of two parallel 6-meter tunnels and two lateral pipes. Boulevards created by the project were progressively opened from 1871 to 1873.

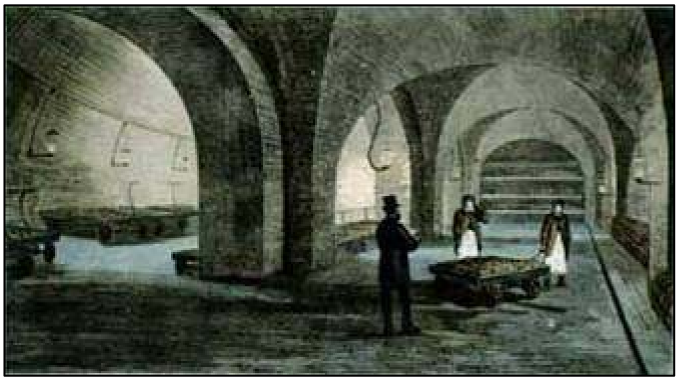
In the mid 20th century, the course of the river was rerouted to the downtown's periphery and in 1976 the disused tunnels were converted into an axis of the subway system. The system today totals about 300 kilometers, of which an explorer can traverse about 12 in a straight line.

The Musée des Égouts offers insight into the working of Brussels' modern sewer network.

Le Musée
des Égouts
€3.00

London

Known as the Victoria Embankment on the Thames' north bank and Albert Embankment on the south, the London floodplain became parks above and sewers and subways below in the later 1800s. Total improvements included 160 kilometers of interceptor sewers, 720 kilometers of mains and more than 21,000 kilometers of local sewers.

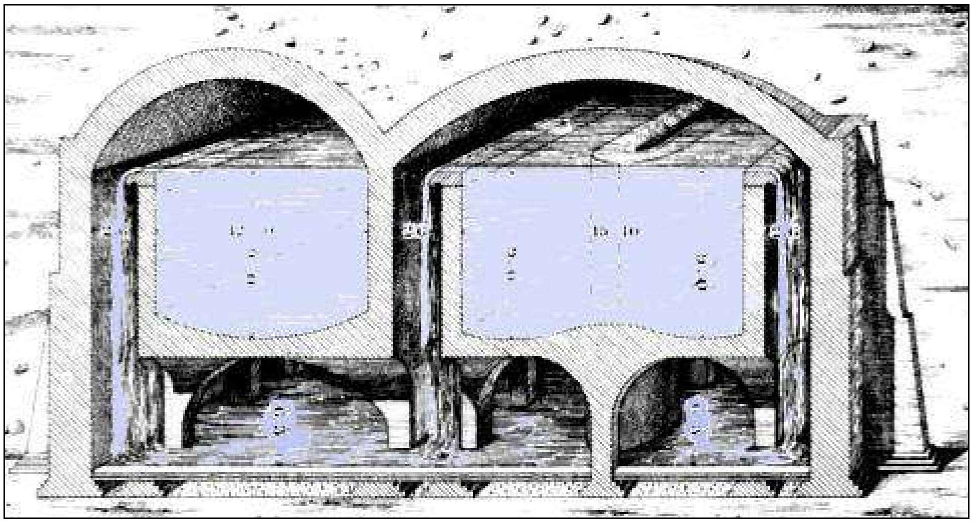


In 1836 the Directors of the Bank of England are said to have received an anonymous letter from a man claiming to have access to the institution's bullion, offering to meet them in the vault at any hour they chose. The Directors thus assembled and at the appointed hour a noise was heard from beneath the floor and the mysterious correspondent emerged from below by displacing a few floor boards.

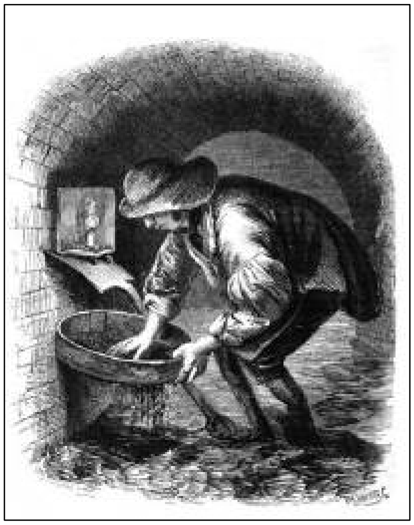
The writer of the letter was a sewerman who in the course of his profession had discovered an abandoned drain under the vault and could have spirited away great sums. But he was an honest man, and for his revelation the Bank is said to have rewarded him with £800.

While the legend's particulars are not verifiable, subsequent correspondences suggest the institution's anxiety that there might be other abandoned waterways providing access.

> In 1837, the Secretary of the Bank wrote to the Commissioners of Sewers asking for plans of the sewers and drains surrounding the Bank building "and as far as can be within the Bank premises also."
>
> Letters were sent to the Curator of the Soane Museum requesting that plans of the drains beneath the Bank should be returned to the Bank.
>
> A February 1839 letter from the Bank Architect to the Building Committee notes, "In May 1836, having had reason to apprehend danger from our sewers, it was discovered that an open and unobstructed sewer led directly from the gold vaults down to Dowgate."



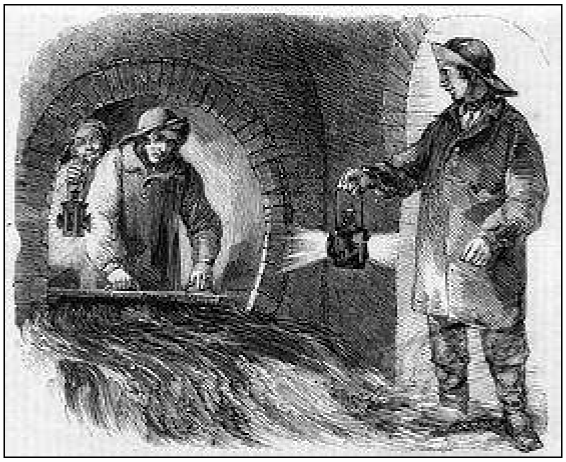
Design of the London system was hydraulically sophisticated, as evidenced by the overflow diversion shown above.



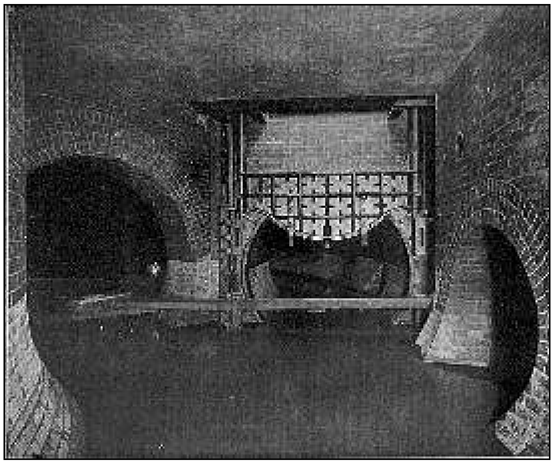
London's some-200 19th-century “toshers” made their living by scouring the sewers for trash and waste to be resold. Toshers earned an average of six shillings a day, ranking them among the better-of of the working class.

Not all agreed, however. From "Life in the Sewers, Living Age, April 12, 1845,

> *Any one who has walked over Blackfriars or Waterloo Bridge when the tide is down, may have observed men and boys, and occasionally women, waling upon the shores of the river, knee deep in the slime, with baskets upon their backs, or slung over their arms, picking up pieces of wood that have been left behind by the tide, or bits of coal that have fallen from the numerous coal barges that come up laden from the pool, where the collier vessels are moored, to discharge their cargoes at the wharfs further to the west.*
>
> *These "mud-larks," as they are sometimes called, bear generally a bad character, being accused of not contenting themselves with the prizes they find on the shore, but of robbing the coal barges or other vessels, on board of which they can creep at nightfall without detection.*
>
> *However this may be, their functions do not end with the shore, but in the sewer. With torch in hand, to preserve them from the attacks of numerous large and ferocious rats, they wade, sometimes almost up to the middle, through the stream of foul water, in search of stray articles that may have been thrown down the sinks of houses, or dropped through the loop holes in the streets. They will at times travel for two or three miles in this way -- by light of their torches, aided occasionally by a gleam of sunshine from the grating by the wayside -- far under the busy thoroughfares of Cornhill, Cheapside, the Strand, and Holborn, very seldom able to walk upright in the confined and dangerous vault, and often obliged to crawl on all fours like the rats, which are their greatest enemies.*
>
> *The articles they mostly find are potatoes and turnips, or bones, washed down the sinks by careless scullery-maids; pence and half-pence, and silver coins; occasionally a silver spoon or fork, the loss of which may have caused considerable distress and ill-will in some house above; and not infrequently more valuable articles, which thieves, for fear of detection, have thrown down when they have been hard pressed by the officers of justice.*



Flushing a London sewer, 1861



Weir Cavern Chamber under Hammersmith Road, 1905

The simulated Victorian sewer ride in today's London Dungeon -- no relation to the Tower of London, please note -- features a Jack the Ripper animatron.

London
Dungeon
£12.95

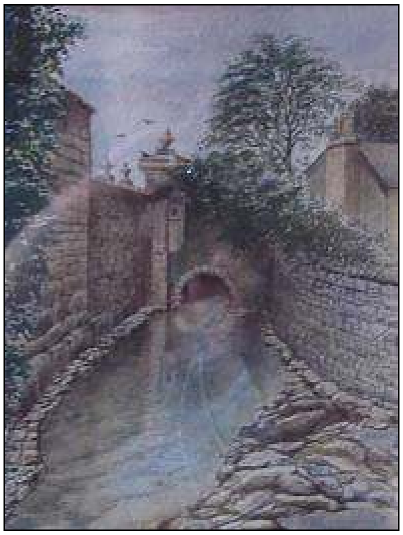
The intrepid can also explore -- albeit by trespass -- the subsurface River Fleet, but we'll leave the details for Chapter 73.

Dublin

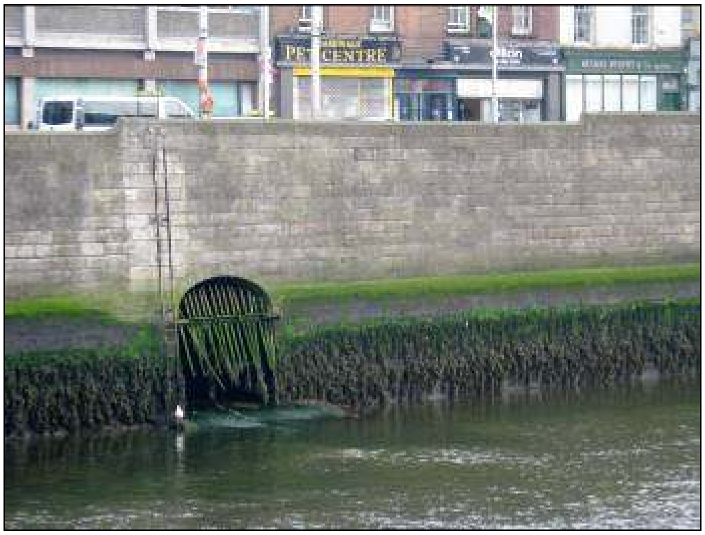
James Joyce (Chapter 16, Underground Rivers in English Fiction) wasn't the first to write of Dublin's underground rivers. From "The Ancient City of Dublin," Catholic World, April 1892,

> *At the other side of Christ Church and its hill there is another descent to the low-lying streets marking the ancient bed of the Poddle, a mysterious subterranean stream, which, leaving its parent Dodder at a lovely green place behind Harold's Cross, slips away from the sunlight and goes sluggishly under houses and streets and becomes a common sewer, till it spills into the Liffey through a side gate in the quay-walls. A dreadful stream it has always seemed to me since I read long ago of a woman falling into it through a trap-door which she had lifted in her little house-yard in order to draw up water. Imagine the helpless creature swirling away into that living grave! Imagine her dead, floating on and on through the labyrinth in the dark! I have never forgotten the horror of it. There is something ghastly about a subterranean river.*

By the 13th century, Dublin's water supply was inadequate and water from the Dodder was diverted to the Poddle. By the late 19th century, the latter was fully enclosed.



One of the few visible sections of the modern River Poodle



The confluence of the River Poddle and the River Liffey, visible at low tide through a grate in the Liffey walls.

Manchester

England's second largest city rose to prominence as an industrial powerhouse in the 19th century. The Manchester Museum of Science and Industry includes a stroll through a simulated sewer crafted from the bricks of an old one, with piped in sounds of scurrying rats, and pumped-in odor.

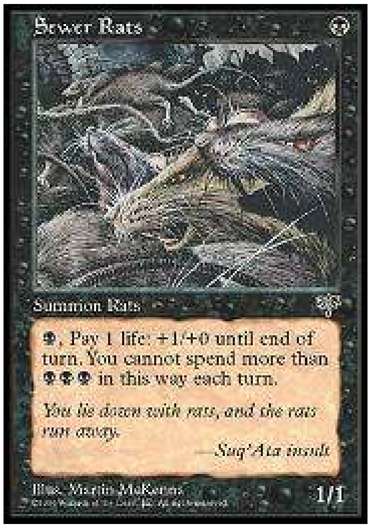
Museum of
Science and
Industry
£4.50

Emmen

This Dutch town has quite ordinary sewerage, but the Noorder Dierenpark zoo features a plexiglassed simulated 19th-century sewer, home to 90 sewer rats, creatures omitted from Chapter 47, Wrecks of Ancient Life, because they're a product of modern life.

Rather than a photo of the Dutch rodents, we exhibit a card from the game Magic the Gathering (Chapter 27, Virtualizing the Imagined: Underground Rivers in Games).

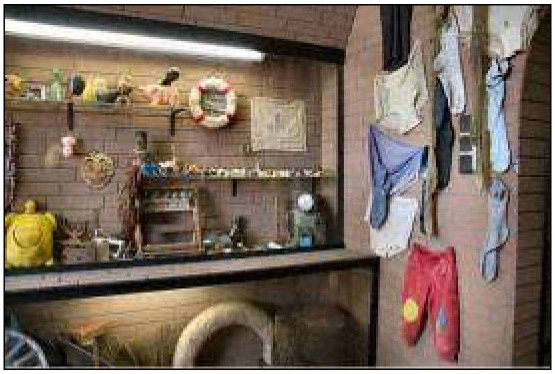
Noorder
Dierenpark
€17.50


Sewer Rats
Summon Rats
, Pay 1 life: +1/+0 until end of turn. You cannot spend more than in this way each turn.
You lie down with rats, and the rats run away.
—Suq'Ata insult
Illus. Martin McKenna
1/1

Hamburg

After the older half of Hamburg burned in the 1840s, the new sewer system was a marvel of innovation, vented through roof drains of the connected buildings and flushed weekly by the tide.

The Abwasser und Sielmuseum (Wastewater and Sewer Museum) includes a wealth of objects fished from the sewers: buttons, dentures, shoes, cigars, bicycles, jewelry, articles of clothing, toys, tins of food, a birth certificate and even a wheelbarrow.

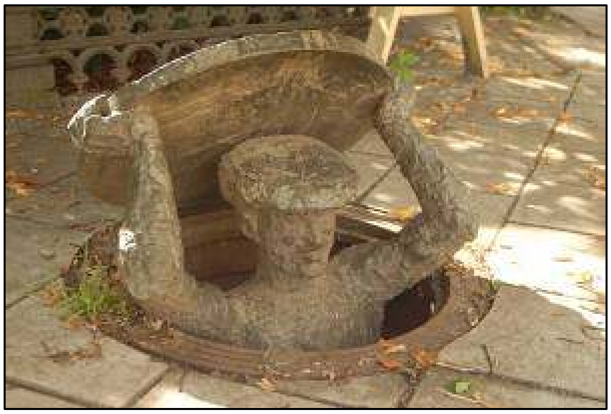


Berlin

We're here just for a movie, The Good German (2006). Sewers are regularly employed to express the subterranean desires and activities and practices in post-war Berlin. Here Lena Brandt makes her way towards her husband's hideout.

773472
The Good German
773472

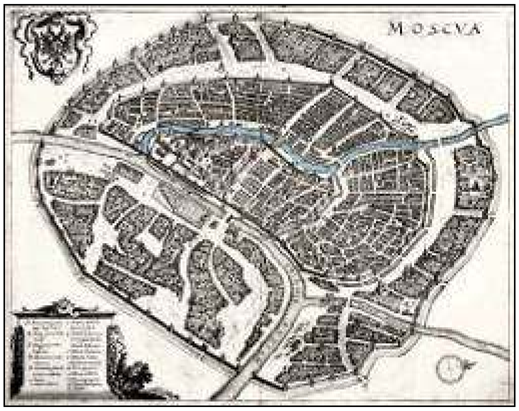
Stockholm



Only a brief stop in the Swedish capital to pay tribute to the Charons of modern times.

Moscow

With electric headlights on their craft, Muscovites can adventure into the 7.5-kilometer Neglinnaya River, a once-natural waterway enclosed since 1817. The river ceased being the official municipal sewer in 1887, so now it's an unofficial one.



1695

Today

The park along the Kremlin wall sits above the river. The youth of Moscow go below.

Warsaw

Another movie stop, Kanał (1956), is about the Warsaw uprising in which a ragged band of resistance fighters try to flee the Nazi onslaught through the city's sewers.

"Watch them closely, for these are the last hours of their lives," announces the disembodied voice of the narrator.

As we're in Poland during Nazi occupation, we'll take a quick jaunt to the city of Lvov (today in the Ukraine, but then it was Polish).

In Darkness (2011) is based upon a true story of a small time criminal who used his employment as a sewer inspector to hide a group of Jews in the sewers for 14 months. The sewers are not stark, grim and deadly like the setting of Kanal. These sewers are smal and inky black, steeped in gloom, cramped and comfortless, wet slime.

The savior does it for money when the story begins, but as the months progress, changes into a fearsomely competent hero who dares to do what others can’t, and that very competency eventually helps humanize him.

CINEMA
In Darkness
ADMIT ONE

Prague

Completed in 1907, Prague's sewer system changed little until the mid-1960s when it was finally upgraded.

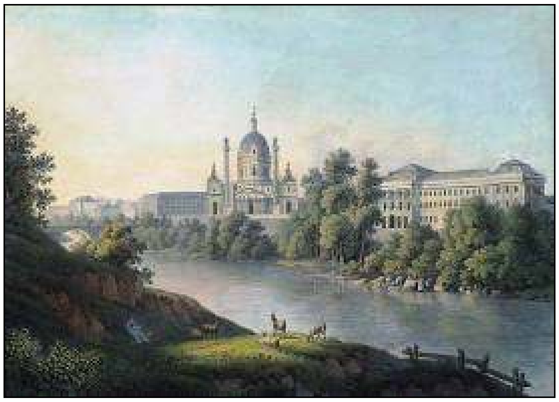
As in Warsaw, Prague's sewer system served as a conduit for the Resistance in World War II.

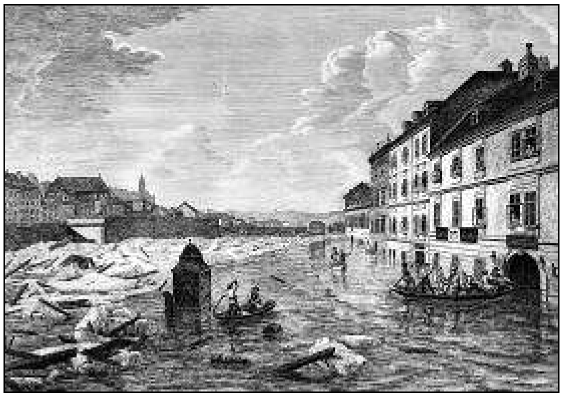
Prague's Ekotechnicke Museum is housed in the first sewage treatment plant of the Austro-Hungarian Empire.

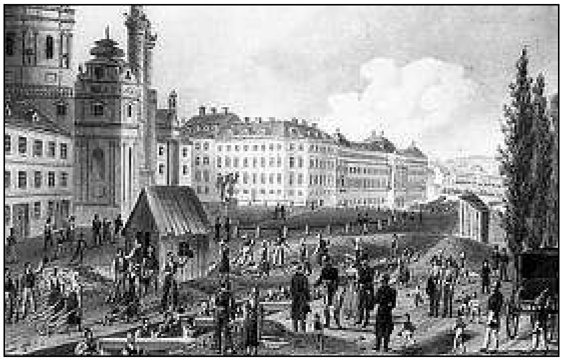
Ekotechnicke
Museum
150 CKZ

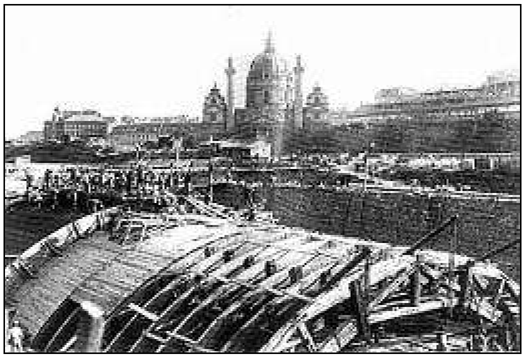
Vienna

By the mid-18th century, central Vienna had well-functioning sewerage, well before other European cities. Conditions in the suburbs, however, were still far from ideal and in 1830, high waters and ice on the Danube led to wide-spread inundation and a cholera epidemic caused by contaminated groundwater killed over 2000. It was then that tunneling began to integrate the watercourses into a combined storm and sanitary sewer system.

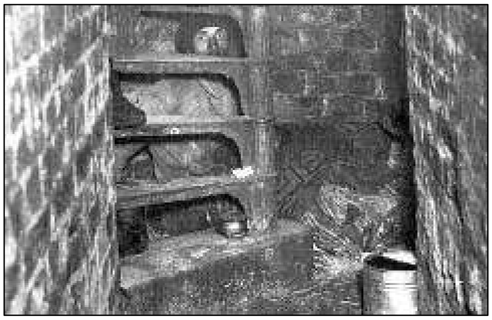








Sewers can create their own social challenges, however. Emil Klager's Durch die Wiener Quartiere des Elends und Verbrechens (Through the Viennese Districts of Poverty and Crime, 1908) called attention to the conditions of the homeless living beneath the city.



Living in the sewers, c. 1900

Graham Greene's The Third Man, written as source text for the 1949 film, elevated the Viennese sewer into noir fiction, par excellence.

THE THIRD MAN
IL 3er HOMBRE
THE 3RD MAN
JOSEPH COTTEN
VALLI
ORSON WELLES
TREVOR HOWARD
CAROL REED
Der dritte Mann
THE 3RD MAN

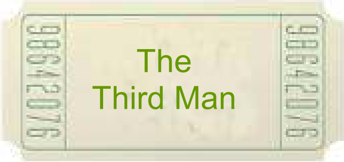
The book version was published the following year.

> *What a strange world unknown to most of us lies under our feet: we live above a cavernous land of waterfalls and rushing rivers, where tides ebb and flow as in the world above. If you have ever read the adventures of Allan Quatermain and the account of his voyage along the underground river to the city of Milosis, you will be able to picture the scene of Lime's last stand. The main sewer, half as wide as the Thames, rushes by under a huge arch, fed by tributary streams: these streams have fallen in waterfalls from higher levels and have been purified in their fall, so that only in these side channels is the air foul. The main stream smells sweet and fresh with a faint tang of ozone, and everywhere in the darkness is the sound of falling and rushing water. It was just past high tide when Martins and the policeman reached the river: first the curving iron staircase, then a short passage so low they had to stoop, and then the shallow edge of the water lapped at their feet. My man shone his torch along the edge of the current and said, "He's gone that way," for just as a deep stream when it shallows at the rim leaves an accumulation of debris, so the sewer left in the quiet water against the wall a scum of orange peel, old cigarette cartons, and the like, and in this scum Lime had left his trail as unmistakably as if he had walked in mud...*
>
> *We moved slowly on, our revolvers trained for a chance, and Lime turned this way and that way like a rabbit dazzled by headlights; then suddenly he took a flying jump into the deep central rushing stream. When we turned the searchlight after him he was submerged, and the current of the sewer carried him rapidly on, past the body of Bates, out of the range of the searchlight into the dark. What makes a man, without hope, cling to a few more minutes of existence? Is it a good quality or a bad one? I have no idea.*

The Third Man film sewer is a labyrinth, vast and sinister, shadowy and echoing, each tunnel leading to another, some large and some narrow, amid twisting and winding staircases. Passages show dead ends. Darkness confounds directions. Flashlight glare bounces of timeworn, shiny stones on curving walls, and flowing water creates a house of mirrors.

In 1999, the British Film Institute designated the film, "Best Film of the Century."

Vienna's Third Man Museum shows clips from the movie in a sewer chamber where a portion of the 7½-minute chase scene was filmed. As negotiating the post-war Vienna underworld would have been difficult for a film crew, however, most subterranean sets were on a London soundstage.



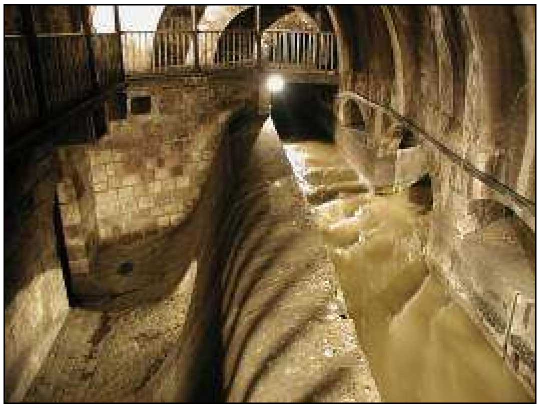
Third Man
Museum
€7.50

The Movie

The Tour

Vienna’s sewer system suffered from 1,800 hits during World War II and not until 1950 was the last of the damage repaired.

Viennese underground rivers of today.



The official City of Vienna Tour covers a small part of the subterranean network, but is hosted by authentic sewer workers who discuss how it is to labor below. There's a multi-media extravaganza loosely tied to the movie and a Welles look-alike who fires a pistol.

Official Vienna
Sewer Tour
€6.50

Not all of today's Viennese underground is museum quality, however.

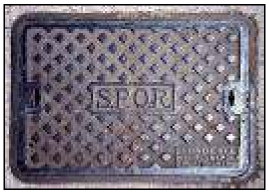
A cinemagraphic aside:

The 1948 noir He Walked by Night was loosely based on the life of Erwin "Machine-Gun" Walker, a former cop who unleashed a crime spree of burglaries, robberies and shootouts in the Los Angeles area, 1945 and 1946.

He Walked... concludes with a dragnet through the L.A. sewers in which the criminal's escape is blocked by the wheel of a police car. As the cops fire tear gas, the outlaw staggers, fires and is shot down, a scene notable for its resemblance to that of The Third Man released the following year.

And as a good sewer scene is worth re-repeating, there's the British sci-fi Invasion (1965) in which an alien spacecraft crash-land near a secluded hospital and the aliens set a force field around the building.

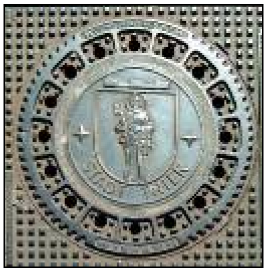
Souvenirs from our Grand Tour



S.P.O.R. --"Senatus Populusque Romanus"

Barcelona

Musée des Arts et Métiers, Paris



Trier

Brussels

London

Dublin

Manchester

Emmen

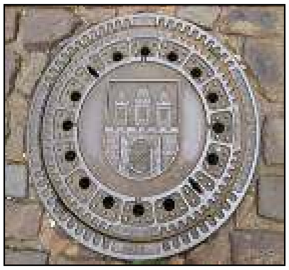
Hamburg

Berlin

Stockholm

Moscow

Warsaw



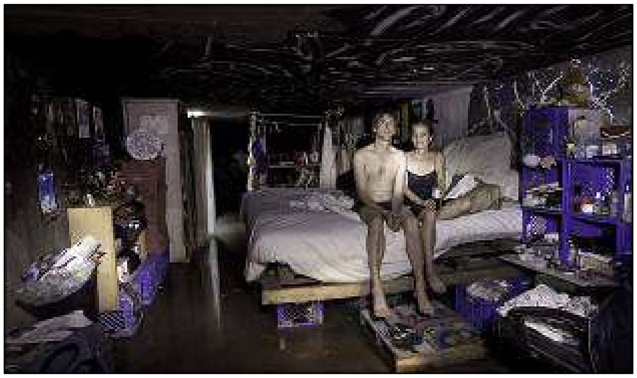
Prague

Vienna

Plus, of course, our movie-ticket stubs.

An Amarican Alternative: Europe + Elvis

Viva Las Vegas!



"Lost Vegas" in the September 24, 2009 Las Vegas Sun described the plight of Steven and Kathryn, whose home the storm sewer beneath Caesar's Palace includes a kettle and a makeshift shower, but their bed and most belongings are on crates to keep them off the wet floor.

There are around 350 miles of flood channels under Las Vegas. Of the city's 14,000 homeless, 700 are thought to dwell under the city's strip.

Another sewer dweller, Amy, who has lived in the tunnels for two years, explains, "The main dangers are the floods and the Black Widow spiders. But it's not a terrible place to be if you're homeless.

Matthew O'Brien, author of Beneath the Neon: Life and Death in the Tunnels of Las Vegas (2007), agrees with Amy's concern.

> *It doesn't rain much in Nevada but when it does the tunnels can fill very quickly. There have been 20 drownings in the last 20 years and a lot of those were people who were living in the tunnels... When it pours down three inches of rain in two hours it's clear it's not a home. It's a flood channel.*

CHAPTER 59
SUBTERRANEAN AQUEDUCTS

The word "aqueduct" may bring to mind Roman arches spanning a valley, but in fact, the definition isn't architectural. An aqueduct is simply a structure -- or more often, a sequence of structures -- constructed to convey water. Most aqueducts are at ground level because that's where construction is the cheapest. Aqueducts are elevated where it's necessary to maintain potential energy. Aqueducts penetrate the terrain where it's easier to drill than to remove or bypass a topographic obstruction.

Most aqueducts are open channels (channels with a free surface), again because of cost, but some systems operate, at least in part, under pressurized conditions.

Wastewater conveyance is the purpose of sewers -- subterranean aqueducts, too, but a less glamorous subset -- the subject of Chapter 58, The Grand Tour, European Sewers of Distinction.

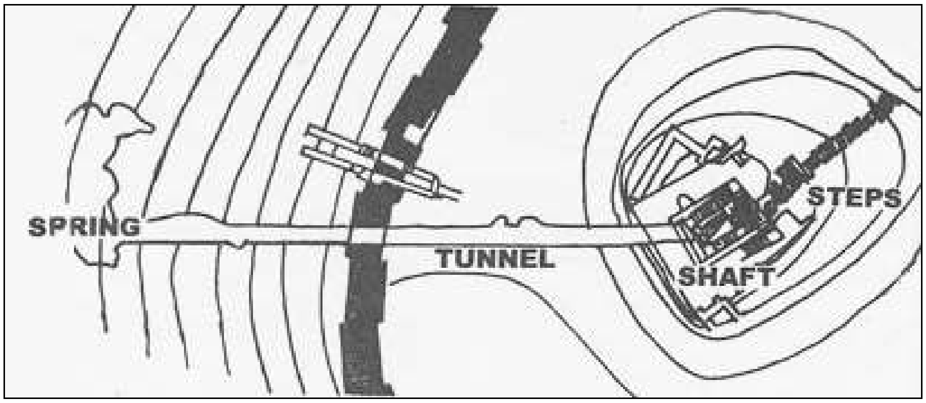
Waterways constructed for navigation also move water, making them aqueducts of another subset, topics of Chapter 57, Cargo Conveyance, and Chapter 67, Tunnels du Canal.

This chapter deals solely with subterranean aqueducts constructed to covey fresh water to users.

Sinnors

Ancient cities of Palestine and Syria developed water tunnels (sinnörs) to hidden springs outside of city walls.

Megiddo, a tell south-east of Haifa, is the inspiration for James Michener's The Source (1983). The source of Megiddo's water was a hidden spring outside of the town's defenses. In the time of Ahab (ninth century BC), a 120-meter shaft, 2 meters high and 1 meter wide, was cut to access the spring.



Jerusalem provides another example.

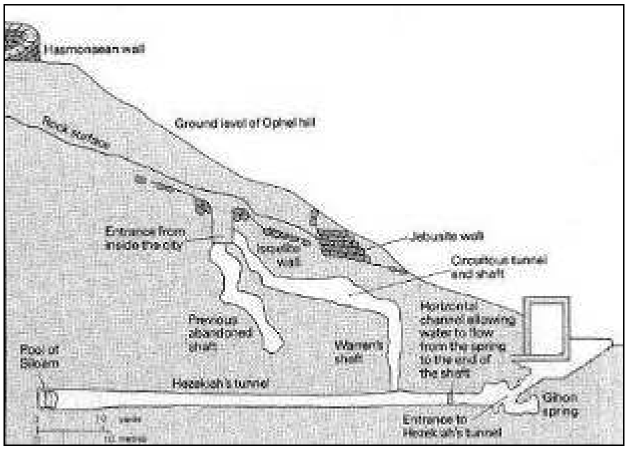
> *And the rest of the acts of Hezekiah, and all his might, and how he made a pool, and a conduit, and brought water into the city, are they not written in the book of the chronicles of the kings of Judah.* -- 2 Kings 20:20

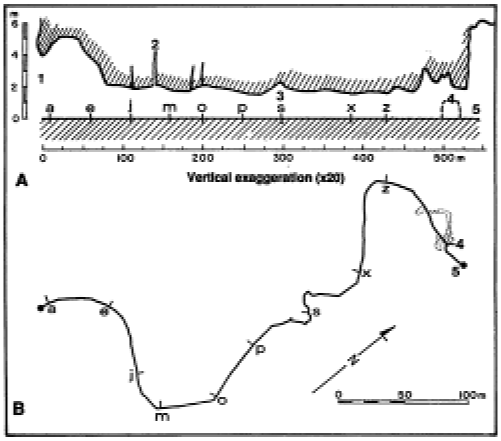
In response to an Assyrian siege, King Hezekiah (eighth century BC) dug from both ends to build a 540-meter sinnor from Gihon Spring to the Pool of Siloam. Tourists today can wade through the tunnel in thigh-deep water.

Hezekiah
12 NIS

Cattle Market Day, Lower Pool of Gihon, 1900

Hezekiah's tunnel's average height is about 2 meters, but increases to about 5 near the outlet.


Hasmonaean wall
Ground level of Ophel hill
Rock surface
Entrance from inside the city
Jebusite wall
Jebusite wall
Circuitous tunnel and shaft
Previous abandoned shaft
Warren's shaft
Horizontal channel allowing water to flow from the spring to the end of the shaft
Pool of Siloam
Hezekiah's tunnel
Gihon spring
Entrance to Hezekiah's tunnel
10 yards
10 metres


m
6
4
2
0
1
2
3
4
5
a
e
j
m
o
p
s
x
z
0
100
200
300
400
500 m
A
Vertical exaggeration (x20)
B
N
0
50
100m

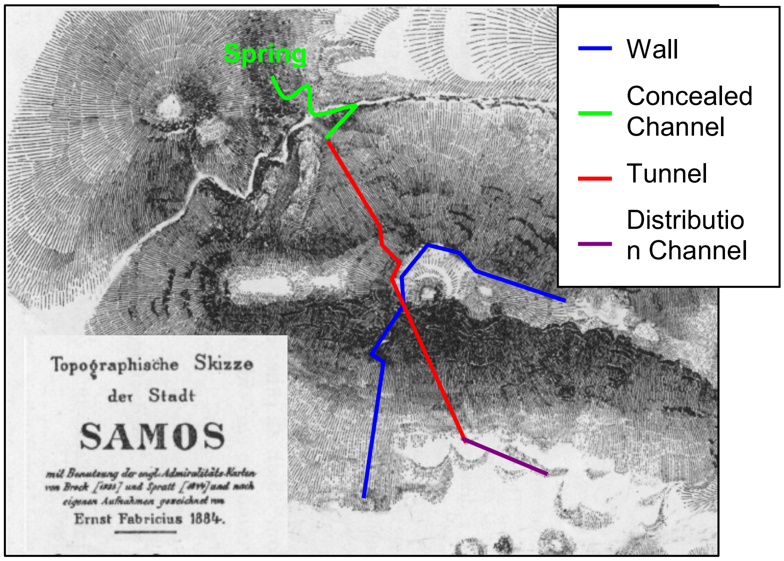
The alignment lurches about, but even still, the two sides met with remarkable precision. An inscription discovered in 1880 describes the achievement.

> *While there were still three cubits to be cut through,* [there was heard] *the voice of a man calling to his fellows, for there was an overlap in the rock on the right* [and on the left]. *And when the tunnel was driven through, the quarrymen hewed* [the rock], *each man toward his fellow, axe against axe; and the water flowed from the spring toward the reservoir for 1200 cubits.*

The meandering pathway may pertain to a siege in 1000 BC in which David captured Jerusalem by calling upon volunteers to enter the city through a secret passage.

> *Whosoever getteth up to the gutter, and smiteth the Jebusites ... he shall be chief and captain.* -- 2 Samuel 5:8

David's men may have slipped in via a natural karst passage which centuries later, Hezekiah simply enlarged.

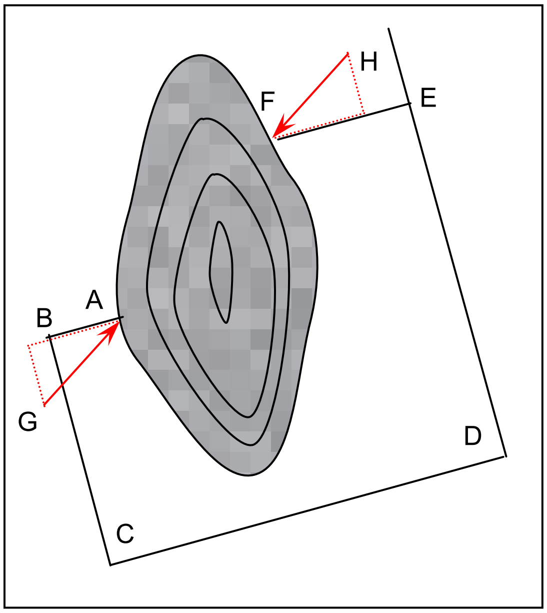

Spring
Wall
Concealed Channel
Tunnel
Distribution Channel
Topographische Skizze
der Stadt
SAMOS
mit Benutzung der engl. Admiralitäts-Karten
von Brock [1821] und Spratt [18..] und nach
eigenen Aufnahmen gezeichnet von
Ernst Fabricius 1884.

The Tunnel of Eupalinos, a 1,036-meter aqueduct through Mt. Kastro, Samos, Greece, was dug in about 530 BC. The aqueduct received water from a concealed spring and a covered channel secreted to the tunnel mouth. A similarly-hidden channel led from the tunnel exit to the city.

The aqueduct is cited by Herodotus' Histories (fifth century BC),

> *And about the Samians I have spoken at greater length, because they have three works which are greater than any others that have been made by Hellenes:*
>
> *First a passage beginning from below and open at both ends, dug through a mountain not less than a hundred and fifty orguia in height; the length of the passage is seven stadia and the height and breadth each eight feet, and throughout the whole of it another passage has been dug twenty cubits in depth and three feet in breadth, through which the water is conducted and comes by the pipes to the city, brought from an abundant spring: and the designer of this work was a Megarian, Eupalinos the son of Naustrophos.*

The Tunnel of Eupalinos is the first known tunnel aligned from both ends by geometry.



Heron's Dioptra (third century BC) describes how to align a tunnel between opposite points A and F in a mountain, a conceptual approach likely used by Eupalinos some three centuries earlier. As we don't know Eupalinos' computational skills, however, we'll assume he only knew addition and subtraction.

Establish a point B near tunnel end A and call this line AB. Turn a right angle from AB and go to a point C far enough that another right angle passes the mountain. Proceed along this line to a point D such that another right angle passes behind the tunnel's other end F. Proceed along this line to a point E at which a perpendicular hits F. Measure distances AB, BC, CD, DE and EF.

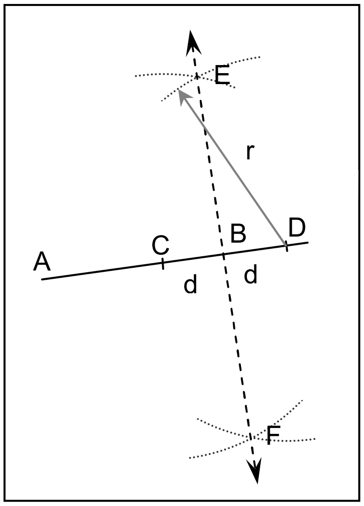
Right triangles having legs of ratio (DE – BC) to (CD – AB – EF) offset from AB and DF establish points G and H. GA and HF, shown in red, are the sighting lines for excavation.

To “turn a right angle” can be done as follows:

To turn a right angle from a line AB at point B, extend AB past B. From B, move both forward and backward on this line an arbitrary distance d, say, 100 “Standard Soldier Heights” to establish points C and D. From C and D, scribe an arc of an arbitrary radius r as shown in the figure. Eupalinos might have done this with a rope. Distance r must be greater than distance d. Points E and F are where the arcs intersect.

Line BE is at a right angle to AB to one side and BF is at a right angle to the other side.

Projecting line BE beyond E will be more precise if the visual sighting is taken from point F (in lieu of B) through point E. Sight from E through F to extend line BF past F.

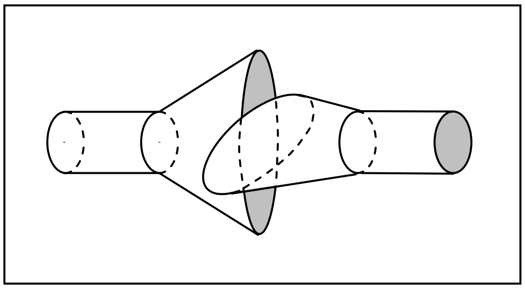


To make the two red triangles in the geometric layout “right triangles having legs of the ratio of (DE – BC) to (CD – AB – EF),” retain the numeric values of distances AB, BC, CD, DE and EF, but change the units to something smaller. 504 “Standard Soldier Heights” becomes 504 “Standard Soldier Elbow-to-Fingertips,” for example. From A or F, move (CD – AB – EF) Elbow-to-Fingertips along AB or EF, make a right turn in the appropriate direction and move (DE-BC) Elbow-to-Fingertips. The result is G or H.

Vertical control tended to be less of a challenge. Eupalinos may have leveled around Mt. Kastro with a chorobates, a grooved 6-meter beam supported on legs. When water poured into the beam's groove was uniformly distributed along its length, the surveyor could project a level line of sight.

When the two sides draw near, flaring one shaft horizontally and the other vertically decreases the chance that the two will shoot past one another.

Correctly guessing that his miners were truer to the vertical than to the horizontal, Eupalinos expanded only moderately in the up-and-down direction, but flared widely, left-to-right.



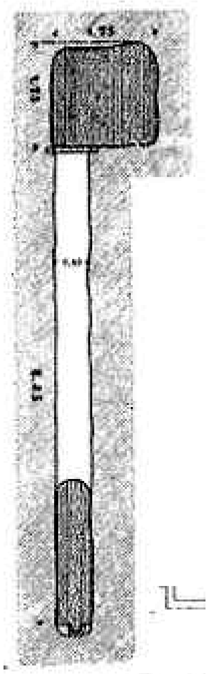
Soil conditions along the north passage forced additional deviations and at least six alignment corrections.

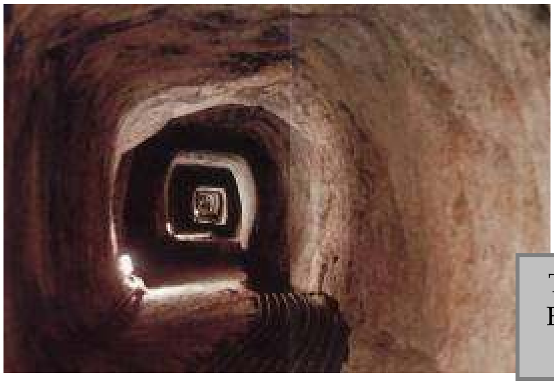
When the digging crews were within earshot, approximately 12 meters for this rock, the tunnels were directed toward each other and met at a dog-leg angle, as shone to the right.

Eupalinos did much better in the vertical. At the rendezvous, the closing error for the two tunnels is just a fraction of a meter.

A typical cross-section is about 1.8 by 1.8 meters, but the northern portion, cut through harder rock, is in places barely wide enough for a worker to pass.

The floor drops only 0.6 meter in its 1 kilometer length, most likely the result of underestimating the slope required for water to flow. A steeper slot, 6 meters deep at the outlet, was cut into the floor at a later date. Grating over the slot in today's tourist-accessible portion can be seen in the photo below.





Tunnel of
Eupalinos
€4.00

The aqueduct served for a thousand years before being forgotten. Drawing upon the writings of Herodotus, archeologists rediscovered the tunnel in 1886.

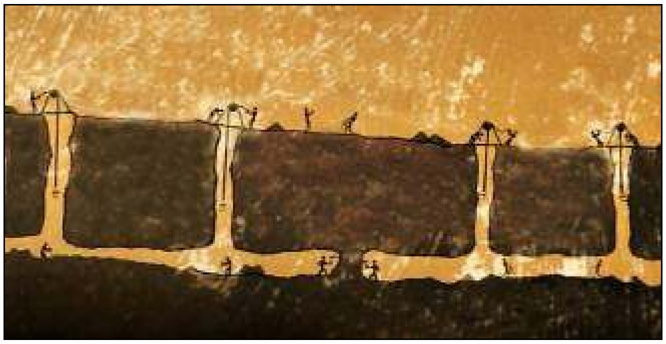
Qanats

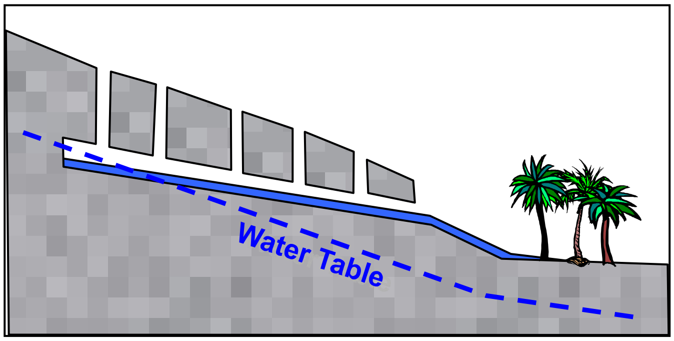
From the journal of Marco Polo (1254-1324),

> *After those three days of desert you arrive at a stream of fresh water running underground, but along which there are holes broken in here and there, perhaps undermined by the stream, at which you can get sight of it.*

"A stream of fresh water running underground" -- the first European report regarding qanats.

Qanats are a traditional Middle Eastern technology of water supply in which vertical shafts, often 10 to 15 meters in depth, are hand-excavated at typically 20 to 30-meter intervals and laterally connected such that groundwater from the highlands drains via a slightly-sloped tunnel to a point of withdrawal. Connecting tunnels are often brick-floored to minimize seepage.





A brief history

Eighth century BC	Persian coal miners improvised qanats to dewater mines. The technology adapted by farmers and spread over the plateau of modern Iran.
Seventh century BC	Assyrian king Sargon II reported finding an underground system for tapping water during Persian campaign.
550-331 BC, Persian rule, Indus to the Nile	Persian rulers provided incentive for qanat construction by allowing profits to be retained for five generations. Qanats constructed westward from Mesopotamia to the shores of the Mediterranean, and southward into Egypt. Qanats constructed in Afghanistan, Turkistan and Silk Road oases, Turfan being an example.
209 BC	King Arsaces of Parthia tried to destroy qanats to sever water supply for invading Seleucidians.
118 AD	Qanats introduced into central and western Sahara by Judaized Berbers.
64 BC to 660 AD, the Roman-Byzantine Era	Qanats constructed in Syria and Jordan, and from there, north and westward into Europe. Qanats part of Roman aqueducts in Lyons and Murcia. Evidence of Roman qanats as far away as Luxembourg. Arab-constructed qanats at Crevillente, Spain, most likely for agricultural use, and at Madrid and Cordoba for urban use, based on Roman systems in southern France.
Post 1520, the Spanish Conquest	Qanat systems introduced in western Mexico. Some qanats in Atacama regions of Peru and at Nazca and Pica in northern Chile may predate Spanish influence.

The term for qanat technology varies regionally.

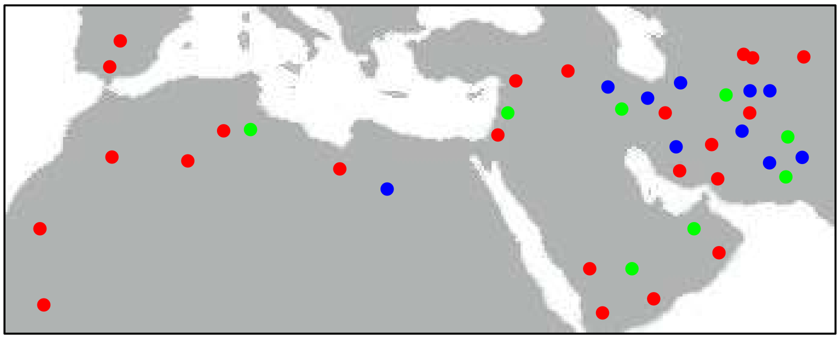
Qanat	Arabic for "lance" or "conduit," a word of Assyrian origin via Hebrew and Aramaic. used in Iran, Jordan, Syria
Karez	Persian in origin, but now used mainly in Afghanistan, Pakistan and Central Asia.
Kanerjing	Western China
Khittara	Morocco
Falaj	United Arab Emirates
Fuqara	Syria, Palestine, and North Africa
Galleria	Spain

Dissemination into northern Africa and western Asia.

● Before Alexander the Great (fourth century BC)

● Before the rise of Islam (eighth century AD)

● The Golden Age of Islam (11th century)



The Turfan (or Turpan) Basin, Xinjiang Province, China, is the second deepest geographical depression in the world, with over 4,000 square kilometers below sea level.

“Karez” means "well" in Uyghur. Dating from the Han Dynasty (206 BC - 24 AD), Turfan's karez qanats conduct snowmelt from the Tianshan Mountains to oases of the Silk Road. In its day, the system's length exceeded 5,000 kilometers, of which 30 were underground. Headwater wells exceed 100 meters while those further downstream were less than 10. Horizontal connectors were roughly 2 meters high.

Russia
Kazakhstan
Mongolia
Turfan Depression
China
India
© Geology.com

Karez remnants remain a tourist attraction.

Karez
CNY 20

Qanats are still employed in Iran, where more than 200,000 kilometers of tunnels deliver nearly 600 cubic meters/second, equivalent to 75 percent of the Euphrates. Qanats yet supply the cities of Tabriz, Tehran and Yazd.

Qanats yet serve more than 70 percent of Oman's water use. A traditional greeting queries about the condition of the system, which evokes the reply, "Insha'allah, it is full."

Roman Aqueducts

The Romans began building aqueducts in the fourth century BC and by 312 BC had 14 systems with a capacity of 1500 cubic meters/day. Most were chopped into the earth, following the contours of the terrain. The smaller the slope, the slower the flow and the less the erosion, but then again, the less the capacity. The average gradient was between 0.0015 and 0.0030, but there was variation, with 6-kilometers of the Carthage Aqueduct at a rapid-like 0.028.

Vitruvius' (Chapter 3) advice,

> *If there are any hills between the city and the fountainheads... tunnels are to be dug... Air shafts are to be at distance of one actus* [40 meters] *apart.*

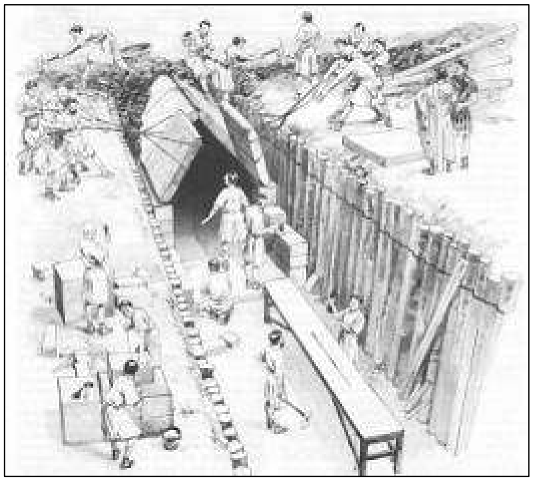
As Roman engineers did not distinguished between rate of discharge and velocity of flow, aqueducts were designed on the basis of conservation of velocity, not mass. Water Commissioner Sextus Julius Frontinus (40-103) attempted to balance system inflow with outflow by sizing intake cross-sectional area equal that of the channel, regardless of the latter's slope. As explained in his On the Water Supply of the City of Rome,

> *Let us remember that every stream of water, whenever it comes from a higher point and flows into a reservoir after a short run, not only comes up to its measure, but actually yields a surplus; but whenever it comes from a lower point, that is, under pressure, and is conducted a longer distance, it shrinks in volume, owing to the resistance of its conduit.*

As long as the aqueducts faithfully served Caesar, Frontinus' superiors didn't question his theory of compressibility.

Soft ground was excavated, the sides shored by timbers. The floor was paved with stone and the walls lined with masonry. Mortar on the floor smoothed the flow. Concrete replaced stone around the time of Christ. When roofed with stone slabs, the trench became an artificial underground river.

Note the chorobates in the sketch.



The **Aqua Traiana**, shown below, was roofed for 58 kilometers.

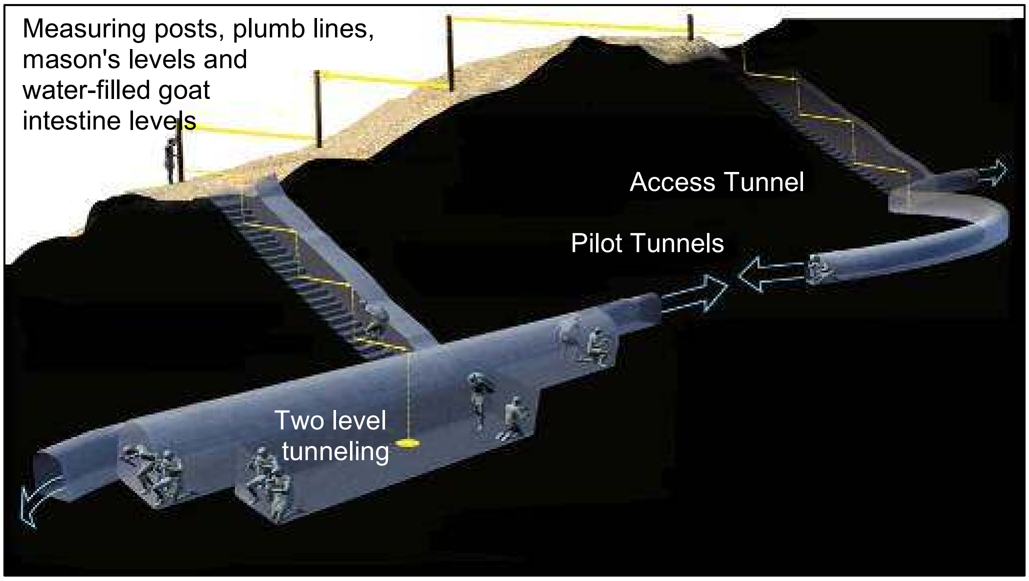
Tunneling was employed only in rare instances, the longest in 52 AD being a just-completed 2.3-kilometer stretch of the Anio Novus Aqueduct. Only as last resort did engineers turn to inverted siphons (Chapter 44) to cross deep valleys.

The 2.3 kilometer record was soon to fall, however, and by a factor of 40.

The Arabic name for the ancient aqueduct to the Jordanian city of Gadara is **Qanat Firaun**, Canal of the Pharaohs. That name is half correct, as the work is indeed a qanat. The aqueduct's not ancient Egyptian, however; it's imperial Roman. Gadara is where Jesus exorcized demons and chased them into a herd of pigs.

The aqueduct began in a Syrian swamp, long since dried out, ran for 64 kilometers on the surface until impassible terrain, and then for 11 kilometers underground. After briefly reemerging to bridge a narrow valley, the terrain became even more grueling and the final 94 kilometers were again below the surface, the longest known tunnel of antiquity.

With an average height of 2.5 meters and a width of 1.5, only four miners -- most likely legionnaires -- at a time could chisel no more than 10 centimeters a day. To expedite the advance, the aqueduct was constructed in the qanat manner with vertical shafts every 20 to 200 meters. Hundreds of soldiers could then labor simultaneously.

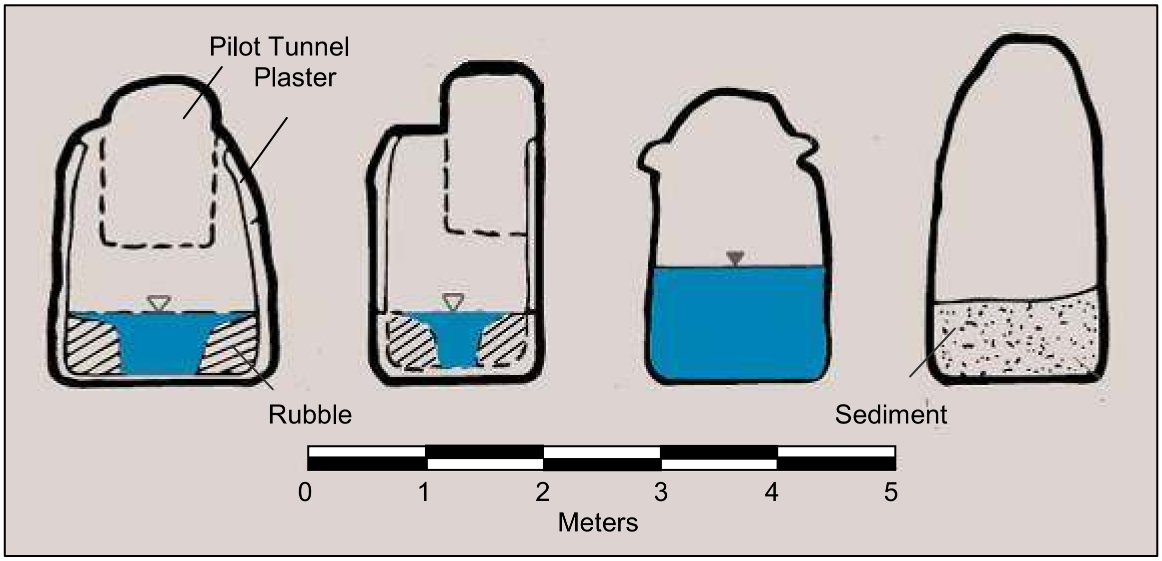

Measuring posts, plumb lines, mason's levels and water-filled goat intestine levels
Access Tunnel
Pilot Tunnels
Two level tunneling

Construction began around 90 AD and continued for another 120 years. The miners chiseled over 600,000 cubic meters of limestone from the ground -- the equivalent of one-quarter of the Great Pyramid of Cheops.

Mineral deposits reveal that 0.3 to 0.7 cubic meters/second second flowed through the structure, a decent flow, but not enough to fill the high stone reservoir built to feed Gadara's fountains and the planned temple.

The Romans appear to have been better excavators than surveyors. For the first 60 kilometers, the tunnel's gradient is but 0.0003, astonishingly shallow. Lateral errors greater than 50 meters appear in almost every phase of construction, corrected by S-curves where recognized in time, but by right-angles if not. The route appears to have progressed to the wrong side of the Wadi Hamra and had to be repeated on the other side.

Elevation variation of up to 2 meters between pilot tunnels could sometimes be accommodated by the connecting slope, but greater errors occasionally required new conduits. One section of the tunnel is bypassed by a passage lowered 1.5 meters.



Cross-sections

The Gadara Aqueduct was never fully completed and was put in service only in sections. The tunnel was not entered by archeologists until 2004 and questions remain concerning its design.

As an environmental aside, the fall of Rome was not due to lead poisoning from the municipal water system. The aqueducts fed the public fountains constantly, precluding sufficient detention time for dissolution. In addition, calcium carbonate precipitate created a barrier between the toxic metal and the passing flow.

More-Recent Aqueducts for Municipal Water

The **Croton**, **Catskill** and **Delaware** subterranean aqueducts constructed from the 1830s through the 1940s to serve New York City are mentioned in Chapter 81, East Side, West Side, All Around the Town.

Construction of the 364-kilometer **Los Angles Aqueduct** from the Owens River began in 1908. The population of Los Angeles was around 300,000; the aqueduct would enable the explosive growth that would characterize the region for decades. Some 4,000 laborers worked at breakneck speed, using new technologies such as the Caterpillar tractor. William Mulholland, an Irish immigrant who'd worked his way up from ditch cleaner to Chief Engineer of the Los Angeles Department of Water and Power, oversaw the project.

The aqueduct included

55 kilometers of open unlined channel,

63 kilometers of concrete lined channel,

158 kilometers of cast-in-place covered conduit,

19 kilometers of inverted siphons, and

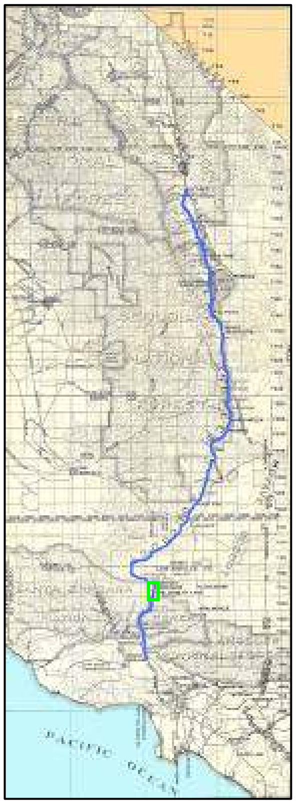
142 tunnels totaling more than 70 kilometers.

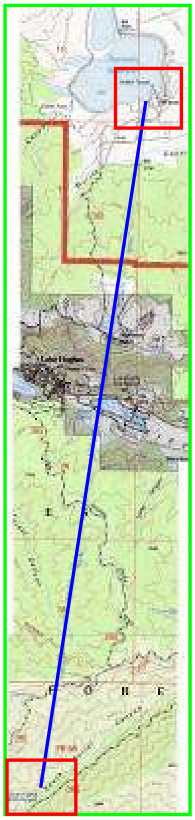
We'll describe the 30 cubic-meters/second Elizabeth Tunnel, at 8.2 kilometers, the longest of the project's tunnels. The tunnel bed is at a grade of only 0.001, but the conduit is pressurized by an energy gradient of 0.0033. Flow velocity is 3.26 meters/second.

California's Coast Range has a double crest with a valley in between. The tunnel is roughly 80 meters beneath the surface

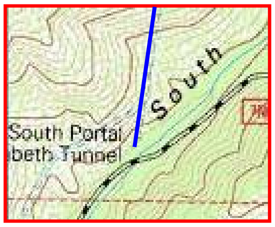
The Elizabeth Tunnel hard rock crew raced with the government men on the Gunnison Tunnel, Colorado (discussed later in this chapter) and beat them, setting the American record for hard-rock tunneling in a single month -- 189 meters in April 1910.

To the right, the map from Complete Report On Construction Of The Los Angeles Aqueduct (1916), Department of Public Service, Los Angeles, and a modern USGS 1:24,000 topo.

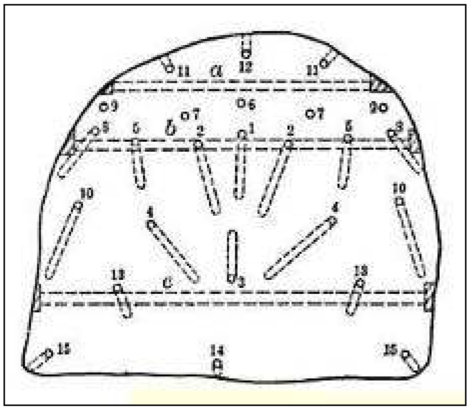




Intake Tower
BM 3048



Breaking Ground


a
b
c
1
2
3
4
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7
8
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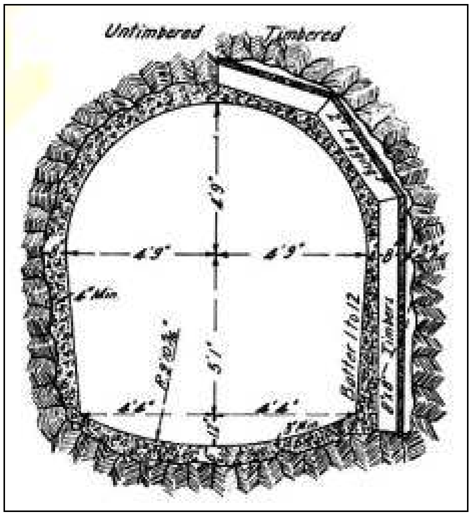
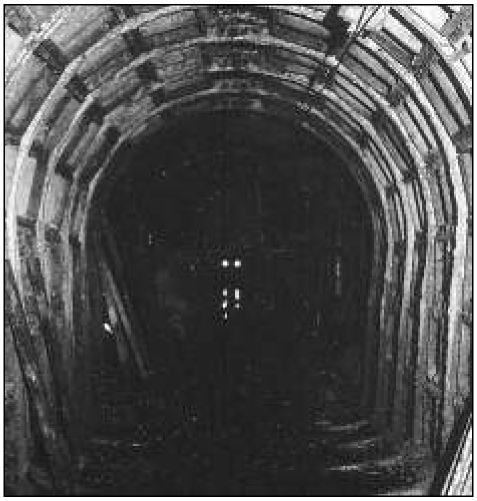
11
12
13
14
15
20

Blasting Pattern


Untimbered
Timbered
4'9"
4'9"
4'9"
5'1"
4'4"
4'4"
4" Min
Batter 1 to 12
8x8 Timbers

Design

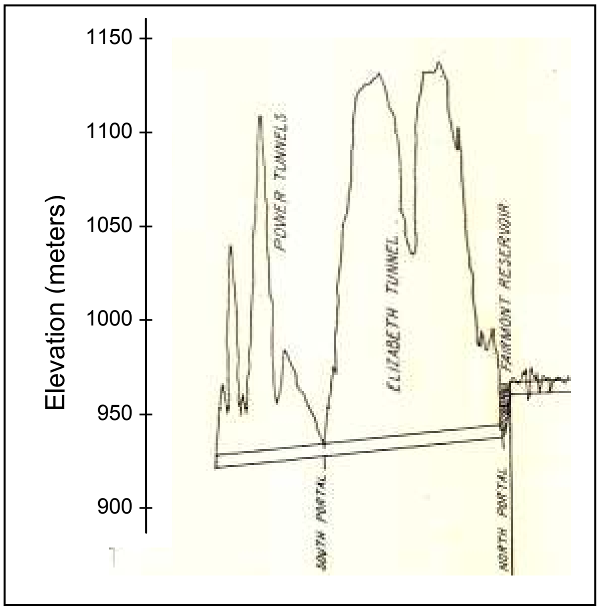


Construction

While the aqueduct's purpose is to supply water to Los Angeles, the elevation of Elizabeth Tunnel allows it to pressurize the penstock of San Francisquito Power Plant #1, an additional project benefit.

Angered that their lands were reverting to desert, Owens Valley farmers blew up portions of the aqueduct in 1924, and again in 1927, a particularly-explosive chapter in the "water wars" that yet divide Californians.

In the early 1940s, the Los Angeles Aqueduct was extended further north through the Mono Basin Project, eventually reaching a total of 544 kilometers.

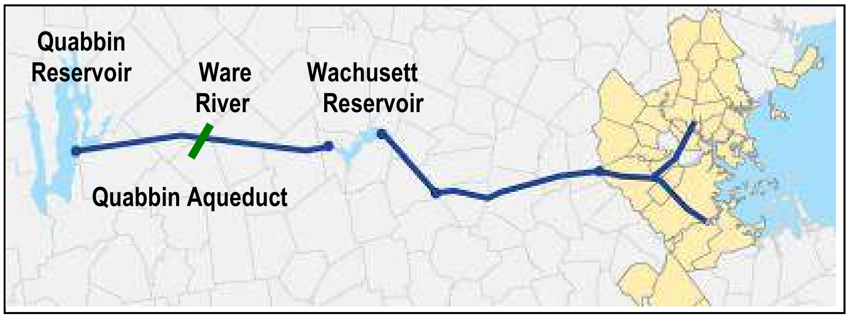


The 39.6 kilometer **Quabbin Aqueduct** supplies drinking water to Boston. Completed in 1933, the concrete-lined horseshoe-shaped rock tunnel, 3.9 meters high by 3.35 meters wide, can deliver 11.3 cubic meters/second.

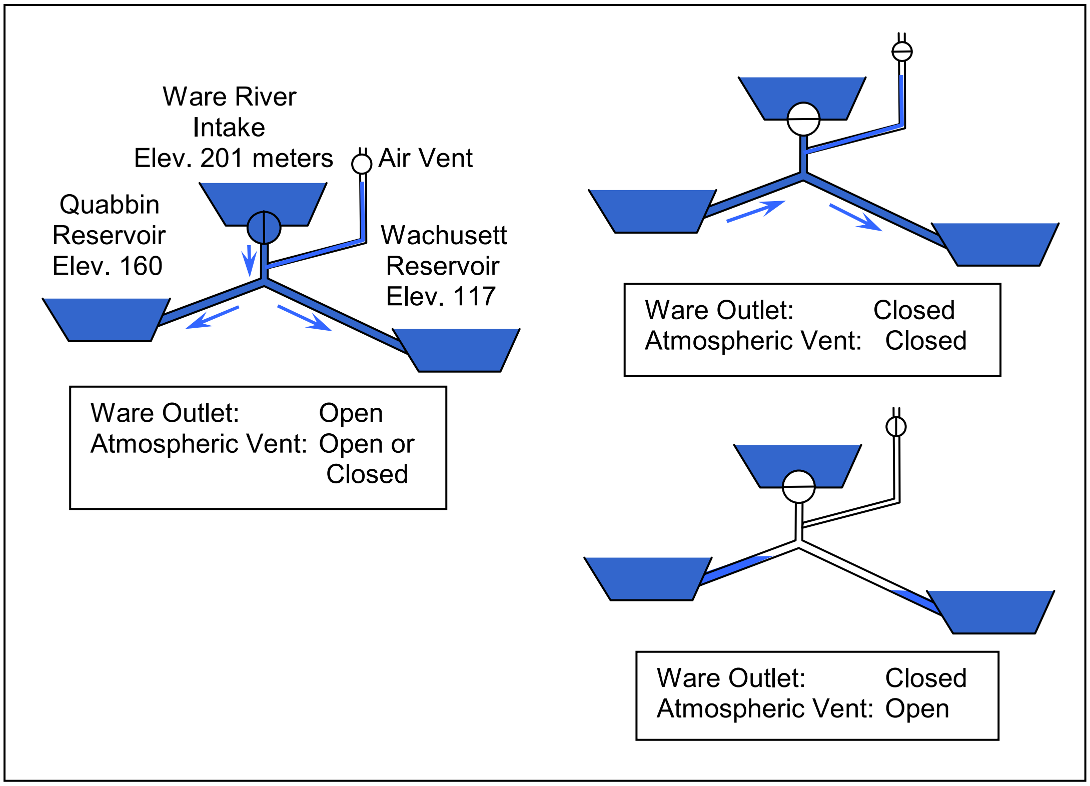
Construction prior to concrete lining.

But Quabbin's no ordinary aqueduct. It can be run in reverse.

The system allows floodwater from the Ware River to be sent both eastward to Wachusett Reservoir (and from there, onward to the consumers) and westward to Quabbin Reservoir where baffle dams enhance the settling of sediment. Water can alternatively be sent directly from Quabbin to Wachusett, or stopped from moving altogether, all of this controlled by just two valves at the Ware Intake, one for water and one for atmospheric air. It's a classic example of a siphon, the subject of Chapter 44.

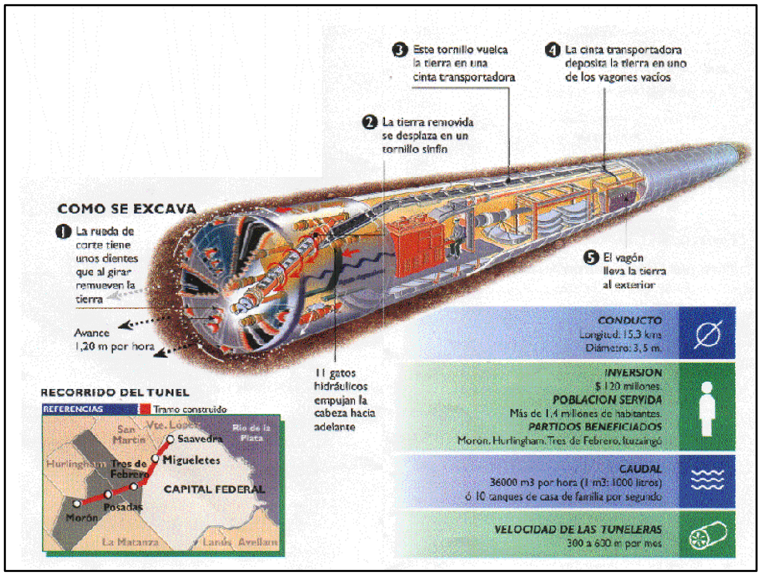


The siphon is primed from the Ware River Intake. Once the Wachusett branch fills and creates sufficient suction, both valves are closed and the Quabbin siphons eastward. The schematic indicates how the system can be operated by opening and/or closing the intake shaft and adjacent air vent.


Ware River
Intake
Elev. 201 meters
Air Vent
Quabbin
Reservoir
Elev. 160
Wachusett
Reservoir
Elev. 117
Ware Outlet: Open
Atmospheric Vent: Open or Closed
Ware Outlet: Closed
Atmospheric Vent: Closed
Ware Outlet: Closed
Atmospheric Vent: Open

Being a siphon, the pipes flow full. The system is gravity-driven until entering the municipal distribution system. Additional gates allow lines to be isolated for inspection and maintenance.

Buenos Aires' water utility Aguas Argentinas' $140 million **Rio Subterraneo** supplies water to 1.2 million residents. The tunnel, 35 meters underground, has a length of 15.3 kilometers and a capacity of 10 cubic meters/second. The conduit was bored at 1.2 meters/hour using similar technology to that used for the construction of the channel tunnel linking Britain and France.

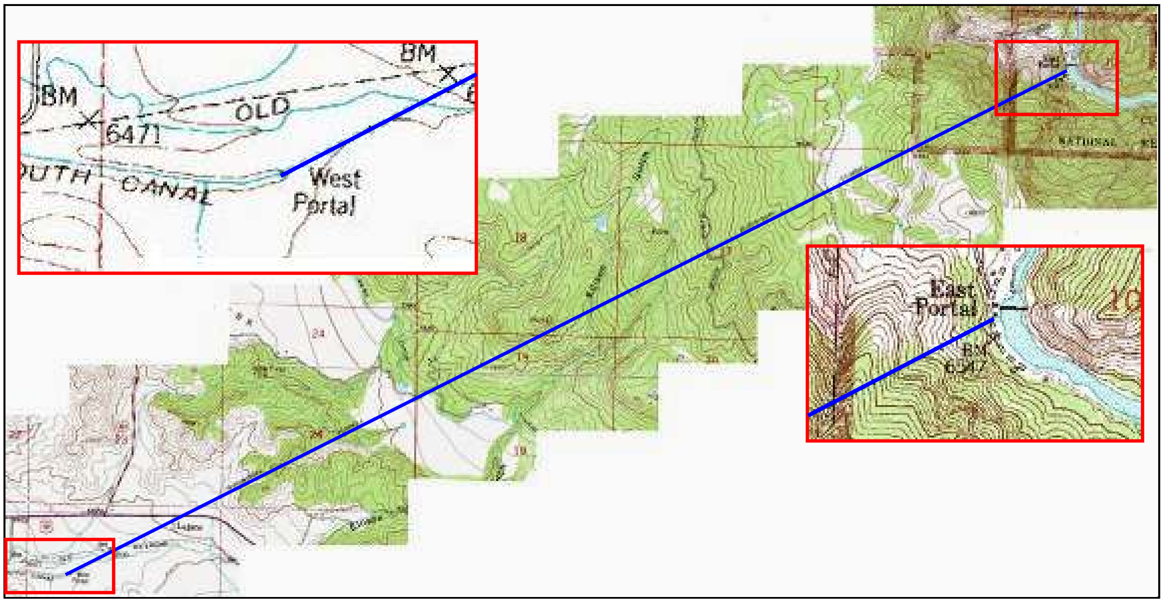

③ Este tornillo vuelca la tierra en una cinta transportadora
④ La cinta transportadora deposita la tierra en uno de los vagones vacíos
② La tierra removida se desplaza en un tornillo sinfín
COMO SE EXCAVA
① La rueda de corte tiene unos dientes que al girar remueven la tierra
⑤ El vagón lleva la tierra al exterior
Avance 1,20 m por hora
11 gatos hidráulicos empujan la cabeza hacia adelante
RECORRIDO DEL TUNEL
REFERENCIAS
Tramo construido
San Martín
Vte. López
Río de la Plata
Saavedra
Migueletes
Hurlingham
Tres de Febrero
CAPITAL FEDERAL
Posadas
Morón
La Matanza
Lanús
Avellan
CONDUCTO
Longitud: 15,3 kms
Diámetro: 3,5 m.
INVERSION
$ 120 millones.
POBLACION SERVIDA
Más de 1,4 millones de habitantes.
PARTIDOS BENEFICIADOS
Morón, Hurlingham, Tres de Febrero, Ituzaingó
CAUDAL
36000 m3 por hora (1 m3: 1000 litros)
ó 10 tanques de casa de familia por segundo
VELOCIDAD DE LAS TUNELERAS
300 a 600 m por mes

As, the truth be told, the project's nothing more than just another big pipe, we're surprised that the December 1998 Journal of the American Water Works Association, a staid publication, took the title at face value and heralded the work, "Underground River to Supply Potable Water."

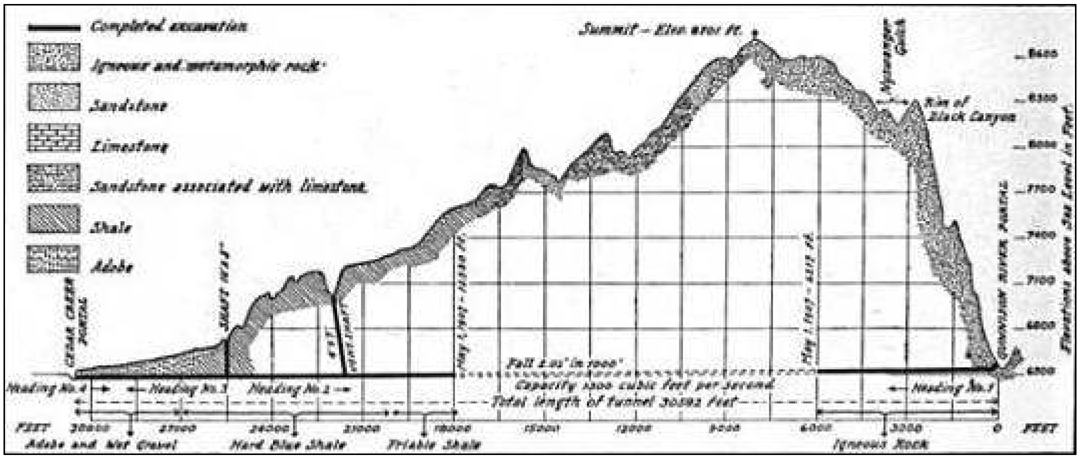
Aqueducts for Irrigation

Gunnison Tunnel is a 9.3 kilometer irrigation tunnel constructed between 1905 and 1909 by the Bureau of Reclamation to divert water from Colorado's Gunnison River to the Uncompahgre Valley. At its completion, Gunnison was the longest irrigation tunnel in the world.

That record was a century ago, of course. Turkey's Sanlıurfa Irrigation Tunnels, completed in 2005, hold today's capacity record, 328 cubic meters/second. South Africa's Orange-Fish River Irrigation Tunnel, 1975, is the now the world's longest irrigation tunnel, 82.8 kilometers. But we'll feature Gunnison because President William Taft isn't otherwise much remembered.

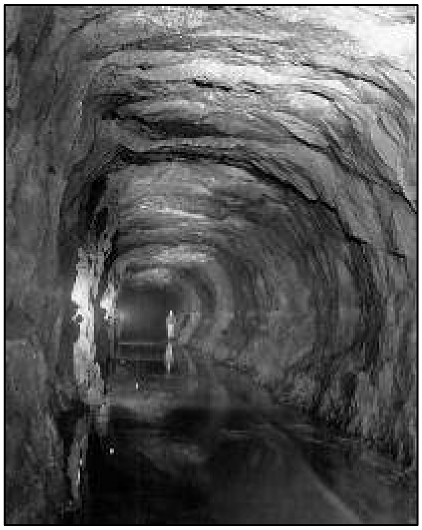

BM
BM
6471
OLD
OUTH CANAL
West Portal
East Portal
BM
6547
NATIONAL

Below, the Gunnison profile from "Running a River Through a Mountain: The Six-Mile Gunnison Tunnel," The World's Work: A History of Our Time 14, August 1907, by Arthur Page.

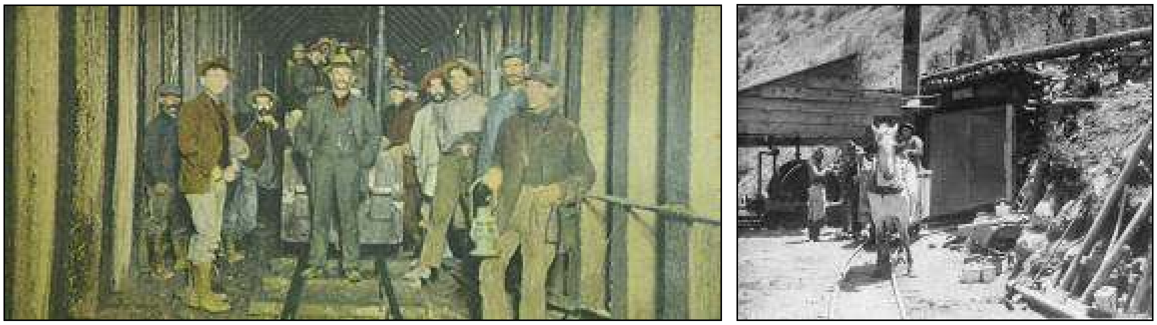

Completed excavation
Igneous and metamorphic rock
Sandstone
Limestone
Sandstone associated with limestone
Shale
Adobe
Summit
Rim of Black Canyon
Cedar Creek Portal
Shaft
Gunnison River Portal
Fall 2.02' in 1000'
Capacity 1300 cubic feet per second
Total length of tunnel 30582 feet
Heading No. 4
Heading No. 3
Heading No. 2
Heading No. 1
FEET
30000
27000
24000
21000
18000
15000
12000
9000
6000
3000
0
FEET
Adobe and Wet Gravel
Hard Blue Shale
Friable Shale
Igneous Rock
Elevations above Sea Level in Feet

Excavation was from each end and two intermediate shafts. About 500 men worked on the tunnel, with the average hire lasting about two weeks.

The tunnel is 3.35 meters wide, 3.65 meters high with arched roof, concrete lined, on a grade of 0.002



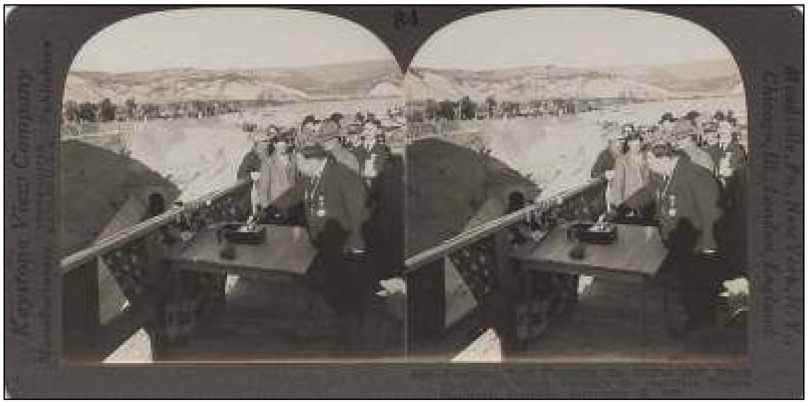
Tunnel yet to be concrete lined

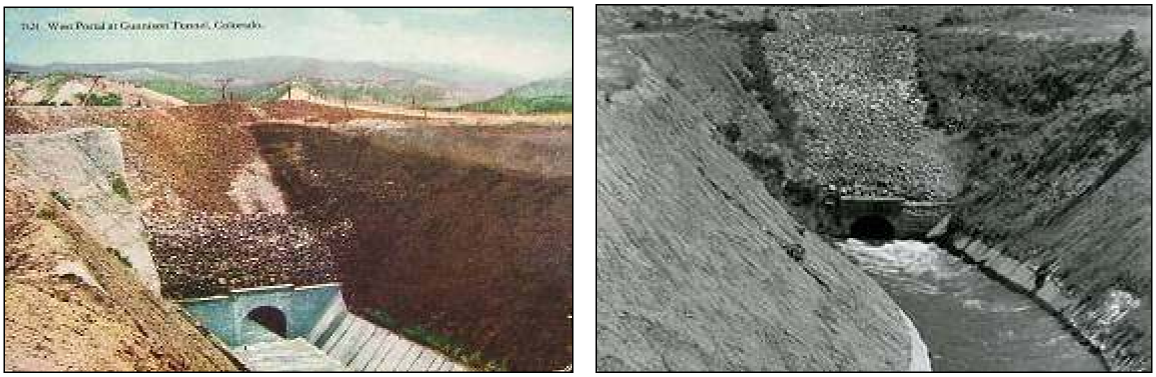


Workers and removal of excavated materials

After five years and 26 fatalities, when the shafts met in the middle, they were offset by only 0.5 meter.

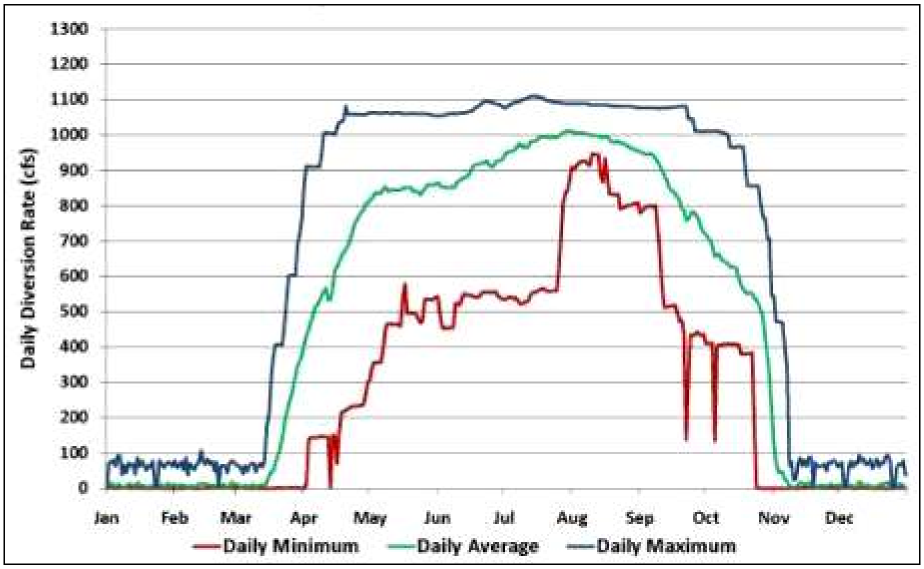
The project officially opened when President Taft pressed a golden bell to a silver plate.





Outlet

Diversions at approximately 30 cubic meters/second generally begin in March and end in October



Daily Diversions, 1991-2010

Unlike the Las Angeles and Quabbin aqueducts, the Gunnison tunnel does not flow under pressure. At the irrigation-season discharge, flow is approximately 2.3 meters deep with a velocity of 3.7 meters/second.

The Gunnison tunnel is not open to boating, but that's not to say the conduit's not been run. In the late summer of 1916, the Kolb Expedition canoed the tunnel in 65 minutes. That's 2.3 meters/second.

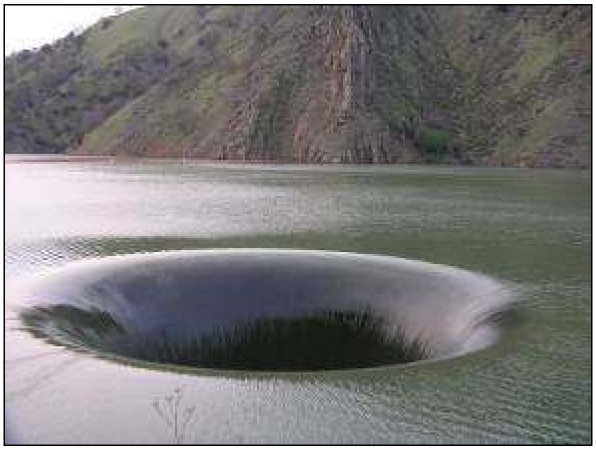
We'll add one final irrigation aqueduct to our survey because it's different. The **Kohala Ditch** once carried water from the rainy mountains to the dry fields of Hawaii's Big Island.

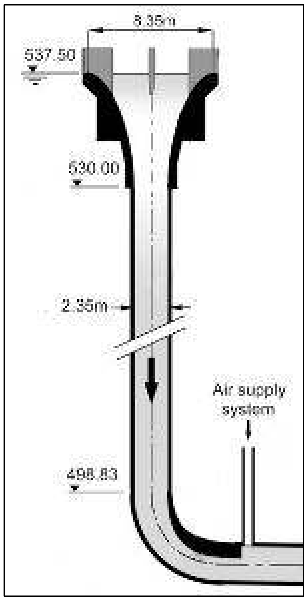
Today's Kohala Mountain Kayak Cruise glides through 10 tunnels, some cut through the porous rock; others coated with mortar. Some curve sharply, leaving kayakers in darkness. Others are arrow straight, a pinpoint of light in the far distance.

The paddle covers nearly 6 kilometers in 2.5 hours.

Morning Glory Spillways

A photo of a morning glory aqueduct inlet caries our thoughts to the subterrain. The glory hole of Monticello Dam in northern California is shown below. Located about 65 meters before the dam itself, water spills over the circular lip when the lake reaches full storage.





Pipelines

We'll end the chapter with a brief look at pipelines, conveyance structures not tunneled, but laid from above and often covered. A water pipe was constructed from the River Thames to London-town in 1236, and since then we've laid a lot more. To broaden our perspective, however, we'll briefly relax the "aque" criteria and consider other sorts of ducts.

Pipelines within the United States (kilometers)

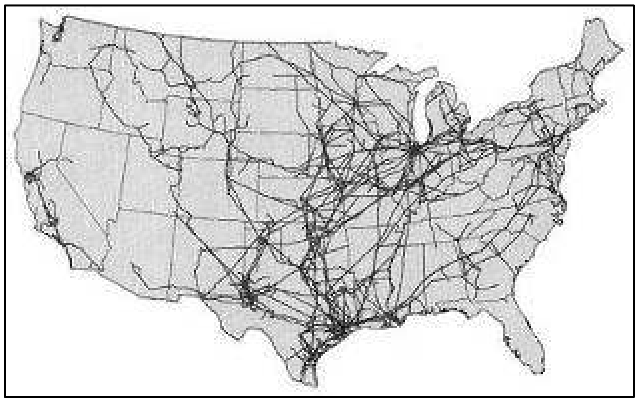
	1960	1970	1980	1990	2000	2002
Petroleum Products	307,280	351,900	351,452	335,937	284,834	259,396
Natural Gas	1,015,366	1,469,689	1,692,584	1,913,738	2,203,567	2,271,287
Water Distribution						2,900,000
Sewer						1,900,000

Note the steady increase in gas pipelines vs. the decrease in those conveying petroleum.

The first petroduct -- our term, we admit, but it seems proper -- wooden, 15 kilometers in length, was built in Pennsylvania in 1865. By 1880, John D. Rockefeller's Standard Oil Company was laying pipelines to Buffalo, Philadelphia, Cleveland and New York. Edison's electric light bulb reduced the kerosene market, but Henry Ford's mass-produced automobiles accelerated the product demand. Pipelines from the prolific fields of Texas and Oklahoma to made Rockefeller the most powerful man in the world.

Interstate pipelines today deliver more than 2 billion cubic meters of petroleum annually, of which 59 percent is crude oil. Pipelines account for nearly two-thirds of the ton-kilometers of petroleum transport.

It takes several weeks to move petroleum products from Houston to New York City, but the cost is only several cents/liter.



A 1954 American Petroleum Institute pamphlet Underground Rivers of Oil by W.C. Kinsolving covers the history, economics and defense aspects of petroleum pipelines. The API assures us that such underground rivers are difficult to bomb.

Another pipeline item:

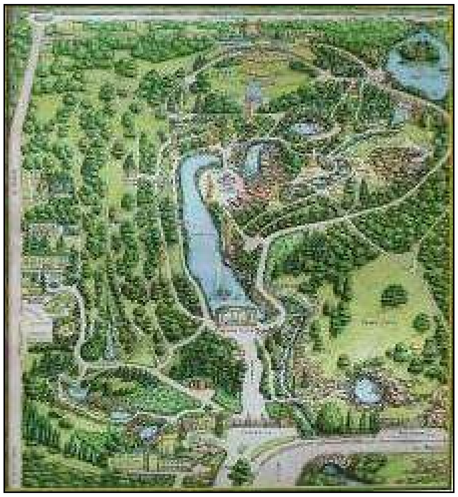
In April 1996, National Pubic Radio scooped plans for a multi-billion-dollar trans-continental coffee pipeline, a javaduct -- so to speak -- from Seattle. Right-of-way negotiations were underway with various governors. Although the source of the coffee was not revealed, it was widely believed to be Starbucks.

Unfortunately for NPR listeners, the broadcast date was April 1.

CHAPTER 60
AMUSEMENT PARKS

Sofiyivka
2 Hr

In 1796, Count Stanislav Potocki began construction of a park to remind his wife Sofia of her Greece. And what could be more Hellenist than an underground river? Kiev's Sofiyivka Park's River Styx runs for 224 meters under the apertures in its granite ceiling.



Quoting from the guidebook,

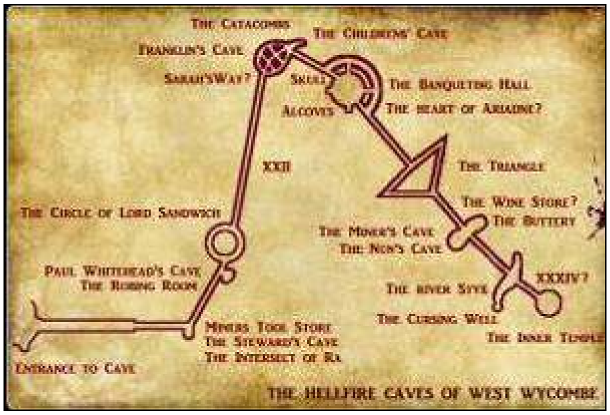
> *Almost all the visitors, particularly in summer time, are eager to make a boat trip along the underground river Acheron after their excursion across the park. Here in a complete silence, in pleasant freshness and coolness, they recover their forces rather fast, get some additional emotional impulse from this unusual place, remembering with appreciation the people who have been carefully maintaining the park for more than 200 years already.*
>
> *Having a rest in the boat, which swings slightly and moves slowly, and watching the wells over your head, you will see a light opening in 8-10 minutes, you will hear the noise of water, rustle of leaves and birds' singing. Gradually it increases and finally you will the sky and find yourself in a round pool surrounded with ash-trees, maple-trees and vine. The water of the Acheron Lake (L.O. Kazarinov named it "Dead lake"), along the open channel and cascade of granite steps, flows under the white iron bridge, which is seen, and falls down into the River Styx as if it is the waterfall; according to ancient Greeks its water joins the water of the Ocean.*

The Russians weren't the first to dig a new River Styx, however. The Great Antrum at the Roman town of Baiae near Naples is a complex of artificial tunnels hewn into volcanic rock as a replica of the legendary Greek Hades. The area is also known as the home of the Sybil in Virgil's Aeneid.

At the end of the entrance tunnel is a fork with a pivoting door. The left passage continues on while the right passage stairsteps down to an underground River Styx, 50 meters long, fed by twin springs. The Romans sealed the site 2,000 years ago. Since its rediscovery in the 1962, this River Styx has been closed to the public due to its dangerous access and sulfurous fumes.

The Hell-Fire Caves were hewn into the chalk cliffs of Buckinghamshire in the 18th century, the design inspired by Sir Francis Dashwood's Grand Tour of Europe and the Ottoman Empire. The caves extend 500 meters underground, the chambers connected by passageways, one of which crosses the "River Styx."

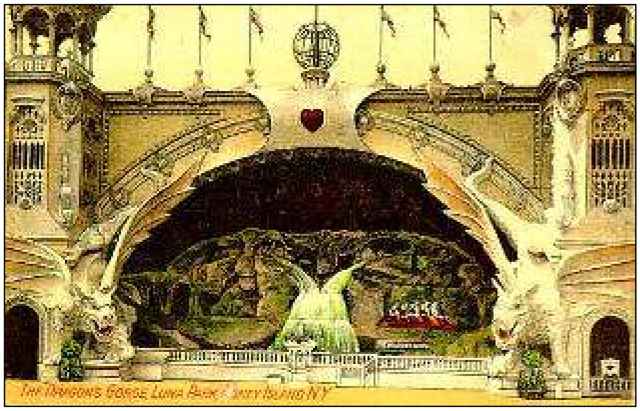
The caves today are operated as spook-house.


THE CATACOMBS
THE CHILDRENS' CAVE
FRANKLIN'S CAVE
SARAH'SWAY?
SKULL
THE BANQUETING HALL
ALCOVES
THE HEART OF ARIADNE?
XXII
THE TRIANGLE
THE WINE STORE?
THE BUTTERY
THE CIRCLE OF LORD SANDWICH
THE MINER'S CAVE
THE NUN'S CAVE
PAUL WHITEHEAD'S CAVE
THE ROBING ROOM
XXXIV?
THE RIVER STYX
THE CURSING WELL
MINERS TOOL STORE
THE STEWARD'S CAVE
THE INTERSECT OF RA
THE INNER TEMPLE
ENTRANCE TO CAVE
THE HELLFIRE CAVES OF WEST WYCOMBE

The first account of the "river" comes from the traveler and diarist, Lybbe Powys, who in 1796 stated that the pool had to be crossed on stepping-stones, whereas previously there had been a boat. In 1863 the pool was described as the "River Styx."

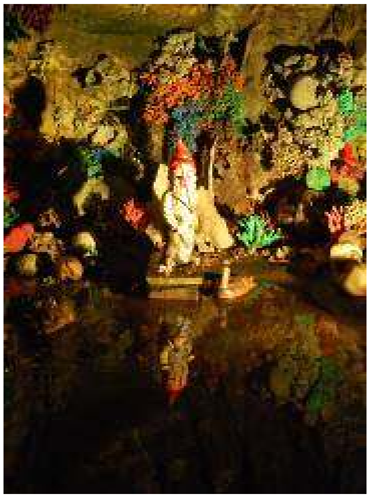
Hell-Fire Cave
£5.00

The original “20,000 Leagues under the Sea” which helped open Coney Island's Luna Park was replaced in 1905 by an indoor scenic railway ride, the “Dragon’s Gorge”, which boasted 10,000 lights and passed along the great waterways of the world, ending with the River Styx. The ride burned in 1944

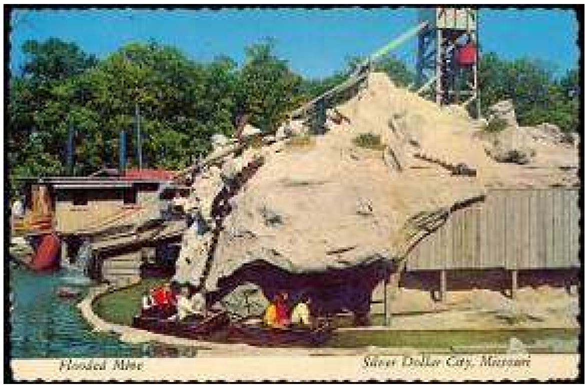

THE DRAGONS GORGE, LUNA PARK, CONEY ISLAND N.Y.

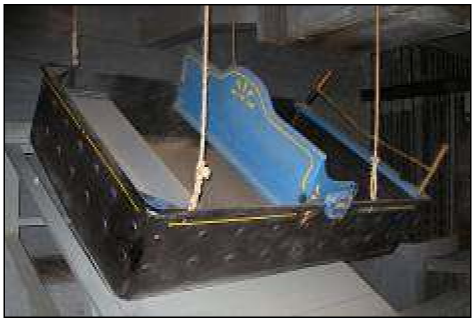
Tennessee's Fairyland Caverns, "the only man-made cave in the world," estends for some 160 meters.

Mirror Lake is its feature attraction. We mercifully show only one of the gnomes.



The Flooded Mine, a dark but gentle underground river ride in Missouri's Silver Dollar City amusement park, became The Great Shootout at the Flooded Mine in 1990, flagrant misuse of even a fake underground river. "Each boat is equipped with pistols that can be used to shoot at targets and ring up points."





Original Silver Dollar City cave boat

Tennessee's sister Silver Dollar City -- today's Dollywood -- likewise featured a Flooded Mine, featuring such state-of-the-art 1970's technology as strobe lights and animatronic characters with rounded TV screen faces.

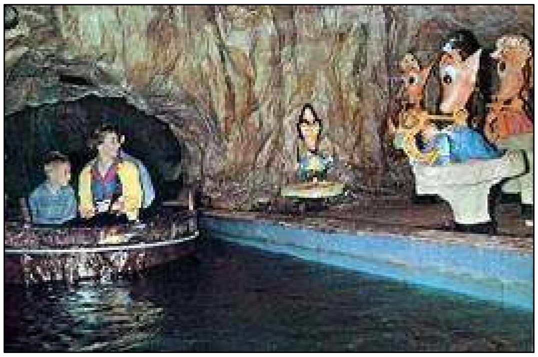
The ride closed in 1997, but remnants of the attraction are yet recognizable to those who fondly remember the original.

The Speelunker (or "Spee-Lunker") Cave was a favorite at Six Flags Over Texas. The boats drifted in a narrow concrete river into a cave opening, dark and cool, a respite from the Texas summer.

Then things become weird.

Grotesquely-cute Spee-Lunkers with tiny bodies, oversized, stalactite-shaped heads and bulging eyes worked busily along the underground river banks. The animations were single-jointed using reciprocating air cylinders or rotating motors without external control and regular, repeating movements.

The original 3-passenger round bumper boats were replaced by 4-person oval-shaped fiberglass craft in the mid 60s.

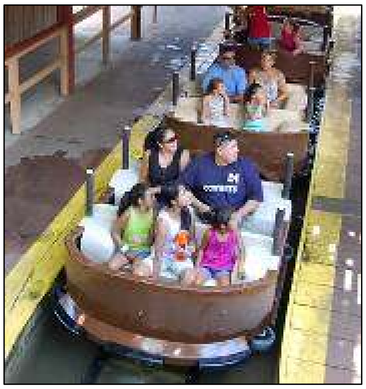


The oval boats had submerged, horizontal rubber wheels that when contacting the flume sides, kept the bow facing forward. A post at each corner assisted passenger seating and employees handling the boat.

The boats were later ganged in pairs, a rod connecting the stern of the first to the bow of the next.

In 1991 the attraction was converted into a cartoonish Yosemite Sam and the Gold River Adventure. Yosemite Sam still uses the ganged oval boats, but the ride's now about Loony Tunes.

Blue dye was added to the water.



It is not true that water moccasins occasionally dropped into the boats and bit the guests, but the urban legend is thought by many to be the reason for the demise of Speelunker Cave.

We made mention of San Marcos, Texas in Chapter 48, Diversity in Darkness, Texas Ecology. The San Marcos Springs are among the greatest in the Edwards Aquifer, a.k.a. the Edwards Underground River, per Chapter 63, The Law of Subterranean Streams.

Here, however, San Marcos Springs merits mention as the location of Aquarena Springs Amusement Park, once one of the "Seven Wonders of Roadside America" where glass-bottomed boats allowed a look at the flooded springs bubbling in the sands below. A gondola provided higher perspective. Ralph the Swimming Pig and frolicking mermaids were trademarks.

AQUARENA
SPRINGS
SAN MARCOS, TEXAS

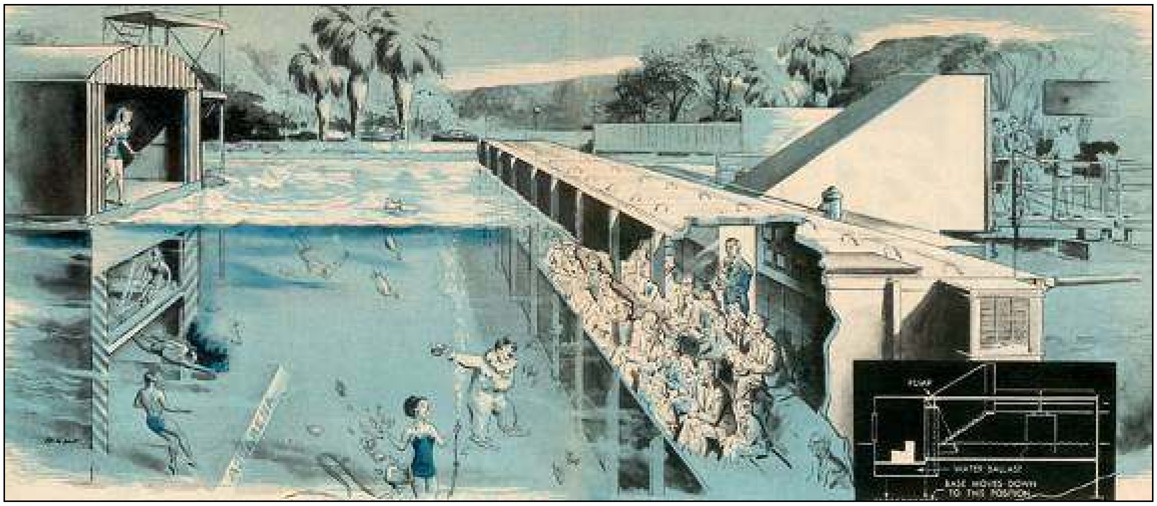
From the June 1952 Popular Mechanics,

50th ANNIVERSARY YEAR
POPULAR MECHANICS MAGAZINE
MERMAID THEATER—page 71
TV GOES TO THE CONVENTIONS
The Cars They Drive Are Classics
America's New Superliner
How to Use Concrete at Home

> *At San Marcos, Texas now boasts a venture unique to both the entertainment and educational worlds -- a theater which allows an amazed audience to witness an hour-long program beneath the surface of a crystal-clear lake. It is a submarine theater which, when a special ballast tank is flooded, takes its cargo of people below the surface.*

The mechanical wonder of the facility was the 100-spectator glass-fronted gallery ballasted to submerge 1.1 meters below the pool surface in 11 minutes.

Glurpo, the World's Only Underwater Clown, below center, was another crowd pleaser


PUMP
WATER BALLAST
BASE MOVES DOWN TO THIS POSITION

Not all were equally amused, however, as suggested by Texas naturalist Del Weniger.

> *Seated in this theater at the mouth of the spring, how can one help but wonder if there is any most unlikely corner of the biosphere humans will not invade and desecrate to their own whims.*

The attraction went out of business in 1996 and Texas State University converted Aquarena into an educational center.

After Disneyland's 1955 opening, Walt Disney proposed attractions for the upcoming 1964 World's Fair that could be moved to Fantasyland when the event was done. Pepsi-Cola agreed to sponsor a UNICEF benefit boat ride and "It's a Small World" came to be.

Disneyland
$42

The 11-minute boat ride, the longest ride in the Magic Kingdom, features international dolls that frolic to the brain-numbing "It's a Small World" melody

The ride has recently been reconstructed for heavier tourists.

It's a Small World is indeed of this world, as the Disney Empire has included it in subsequent theme parks.

Walt Disney World, Florida

Tokyo

Hong Kong

Paris

The Small World theme has been ruthlessly pirated elsewhere.

Small World rip-off, Suzhou Amusement Land, China

Kernie's Wunderland,
The Netherlands

Hyland Hills Water World,
Denver

Dickens World,
London

For the daring, caverns are common to chute rides.

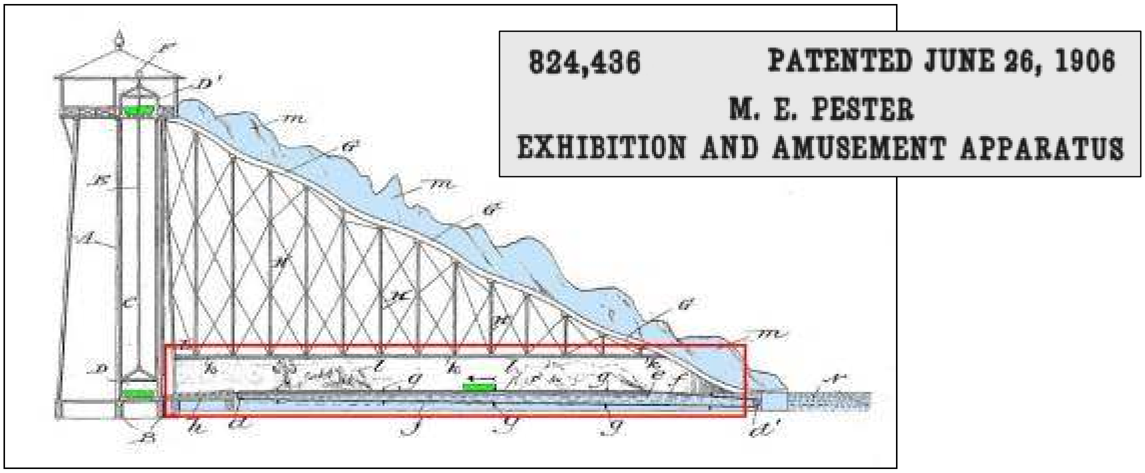
Schlitterbahn, Texas

Valley Fair, Minnesota.

Valley of Waves, South Africa

Patents

The patented Exhibition and Amusement Apparatus predates and out-adrenals Splash Mountain, as this boat's not anchored to a track. Note the size of the craft (highlighted in green) vs. the magnitude of the turbulence.



824,436 PATENTED JUNE 26, 1906

M. E. PESTER

EXHIBITION AND AMUSEMENT APPARATUS

Most of the patent is concerned with the elevator, but we're more interested in the red box.

From the patent documentation,

> *Also the escalator to convey the boat from the lake to the for of the tower and there deposit it on the elevator may be arranged as over dry land, so as to give the effect of the portage or tramway instead of being submerged in the water and arranged in connection with the lake, simulating an underground river. I very much prefer the latter, however, because then the underground effects and other illusions and pictorial schemes may be more effectively and attractively carried out.*

Which is to say that the craft could be hauled to the elevator on a track, but the experience will be better if the transit resembles a voyage on an underground river,

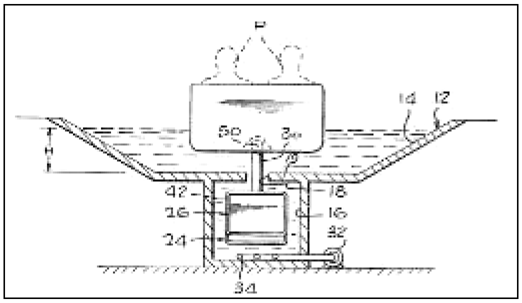
And another patent, "Boat Ride for Amusement Park," 3,930,450, January 6, 1976:

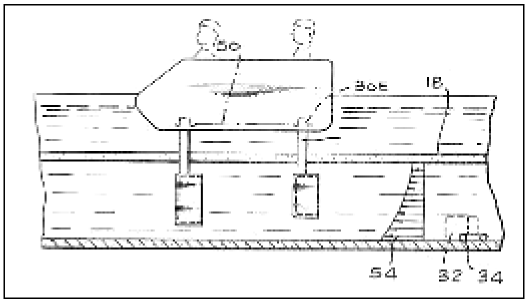
Description:

> *Amusement parks often have "dark rides" in which people are seated in boats that float along a channel that carries them past animated displays. The boats are typically moved along the channel by pumping water along the channel. The cross-sectional area of a boat is typically only a small fraction of the cross-sectional area of the water-filled portion of the channel, so that a large amount of water normally must be pumped through the channel. While this transport system provides a smooth and vibration-free ride, it has several disadvantages. The propulsion system is inefficient, and it is difficult to provide sharp turns along the waterway inasmuch as at such turns the water swirls so that it tends to tip the boat rather than propel it and the water also tends to ride up the outer side of an open channel.*

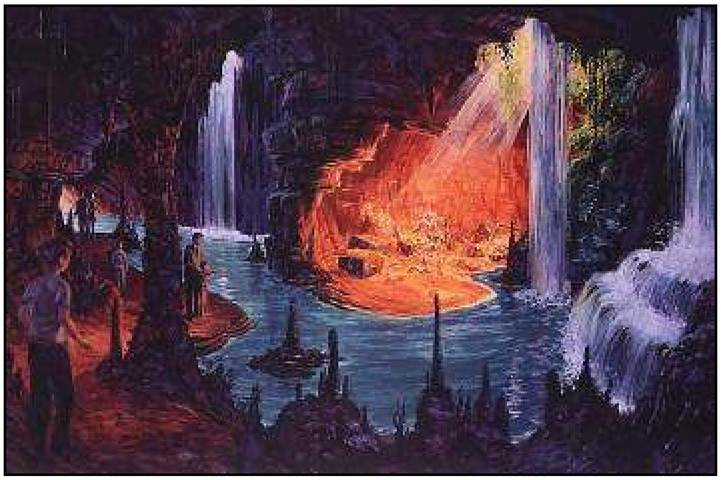
Summary of the Invention

> *A boat ride apparatus is provided which enables boat propulsion with a minimum of power and along tightly curved paths. The system includes a shallow main channel and an auxiliary channel lying beneath the main channel and isolated from it except along a slot that connects the channels. A boat for carrying people includes a hull floating in the main channel, a pair of paddles lying in the auxiliary channel, and a pair of supports extending through the slot and joining the paddles to the hull. Pumps are provided that move water only along the auxiliary channel, to push the paddles and thereby propel the boat.*





Underground Rivers that Never Came to Be

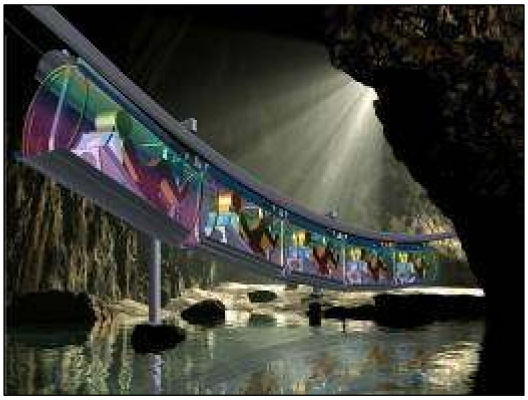


And then there are those underground river rides that never materialized.

To the right, a concept drawing for Treasure Island Cave at Disney World, never implemented.

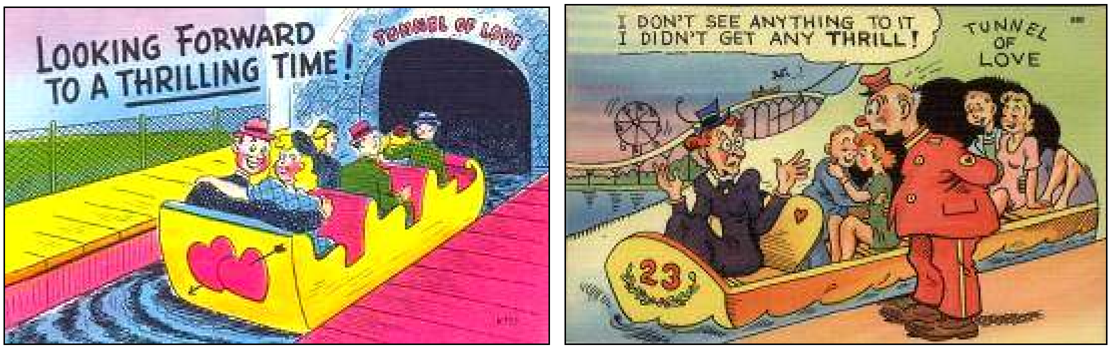
Designers proposed two alternate ways in which to enter Michael Jackson's intended "Peter Pan's Neverland," both of which would have been attractions in themselves. In one, visitors would arrive by an aerial ride. The other would have been by boat through mysterious caves.

We're not sure whether to classify the Shweeb Monorail as a way to access a subterranean formation or as a futuristic ride that happens to pass through a cavern, but here's a marketing illustration.



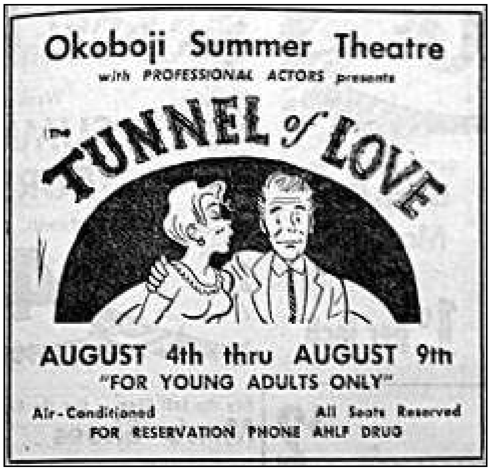
The Tunnel of Love

A "dark ride" is an amusement park attraction in which guided vehicles travel through specially lit scenes, typically containing animation, sound, music and special effects. The Tunnel of Love is a dark ride in which pairs of riders are taken -- usually by boat -- through dark passages. Spooky frights provide excuse for physical contact. As with Patent 824,436, rowing is unnecessary.


LOOKING FORWARD TO A THRILLING TIME!
TUNNEL OF LOVE
I DON'T SEE ANYTHING TO IT I DIDN'T GET ANY THRILL!
TUNNEL OF LOVE
23

Vintage Postcards

TUNNEL OF LOVE



Okoboji Summer Theatre
with PROFESSIONAL ACTORS presents
THE TUNNEL of LOVE
AUGUST 4th thru AUGUST 9th
"FOR YOUNG ADULTS ONLY"
Air-Conditioned All Seats Reserved
FOR RESERVATION PHONE AHLF DRUG

Across the Hudson from New York City, Palisades Amusement Park replaced its old Tunnel of Love boats with chariot-style cars that traveled along a track. The ride was later redesigned with an Arabian Nights theme. The attraction was then renamed Casper's Ghostland, its caverns populated by such characters as Casper, the Villainous Ghostly Trio and Spooky, the Tuff Little Ghost.

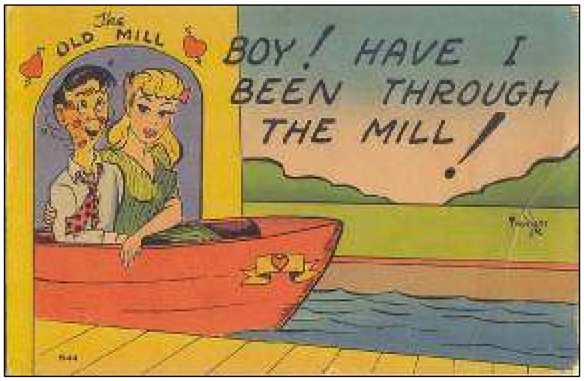
SAVE 95¢
6 BIG RIDES plus ADMISSION and FREE PARKING
$1.60 for only 65¢
NO OTHER CHARGES
GOOD ANYTIME Day and Night Sats. and Suns.
PALISADES AMUSEMENT PARK
937590
SAVE $1.10 with this SPECIAL DISCOUNT TICKET
PALISADES AMUSEMENT PARK
$2.35 VALUE
$1.25
6 BIG RIDES plus ADMISSION and FREE PARKING
GOOD ANY TIME · DAY & NIGHT · SAT. SUN. & HOLS. · ENTIRE 1971 SEASON
657772

As with Palisades Amusement Park, not many tunnels of love remain in operation today, the Gröna Lund in Stockholm being an exception.

Gröna Lund

Kansas State Fair

Debuting in 1921, Ye Old Mill, the 500-meter Iowa State Fair tunnel of love passed by mangy stuffed bears and dioramas of teepees. Renovated in 1996, the sights were replaced by vintage fair posters. The Kansas State Fair has a like-named boat ride (above), but it's a horror tunnel.


The OLD MILL
BOY! HAVE I BEEN THROUGH THE MILL!

1952 Posatcard

The tunnel of love is an established theme of popular music. When Bruce Springsteen's marriage ended, he sang,

It ought to be easy ought to be simple enough
Man meets woman and they fall in love
But the house is haunted and the ride gets rough
And you've got to learn to live with what you can't rise above
If you want to ride on down in through this tunnel of love

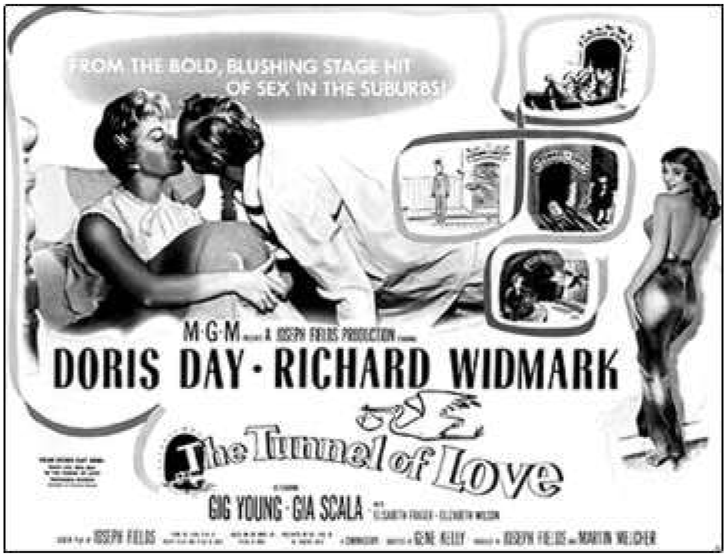
Or take the British band, Dire Straits,

And the big wheel on turning neon burning up above
And I'm just high on the world
Come on and take the low ride with me girl
On the tunnel of love

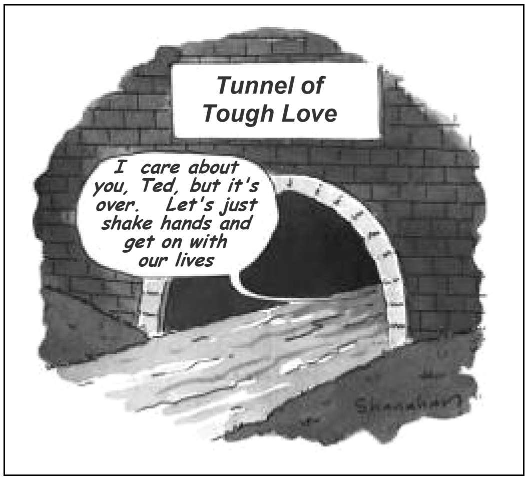
And of course, there have been the movies.

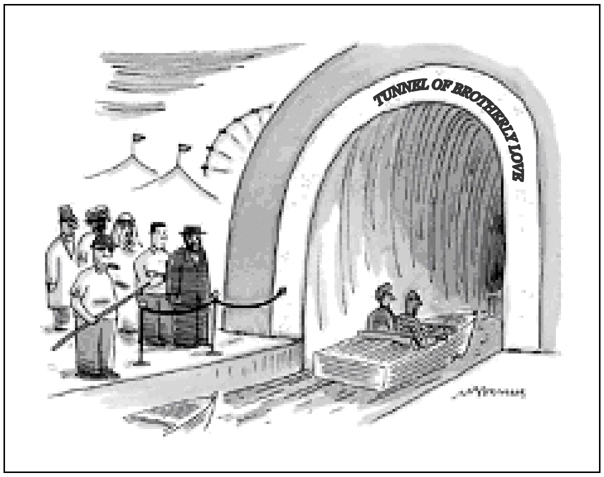
Billed as "Sex in the Suburbs!" and shot in three weeks on a single set, Doris Day and Richard Widmark play a couple battling the bureaucracy of adoption in Tunnel of Love (1958). The film was hated by Day's fans and the actress blamed its failure on a poor script.

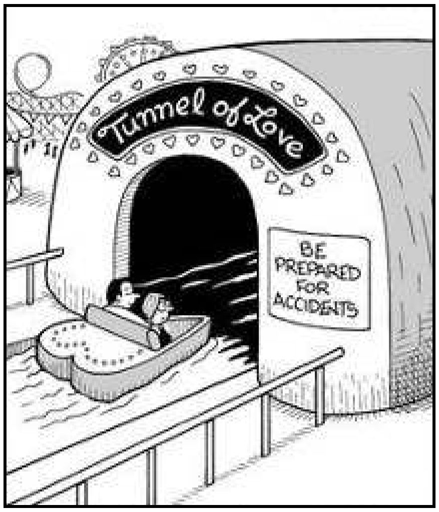
1958 Theater
Admission
$0.75

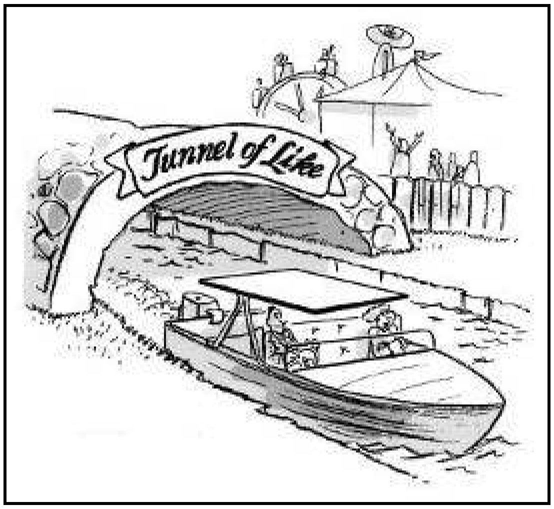

FROM THE BOLD, BLUSHING STAGE HIT OF SEX IN THE SUBURBS!
M·G·M A JOSEPH FIELDS PRODUCTION
DORIS DAY · RICHARD WIDMARK
The Tunnel of Love
GIG YOUNG · GIA SCALA
JOSEPH FIELDS
GENE KELLY
JOSEPH FIELDS MARTIN MELCHER

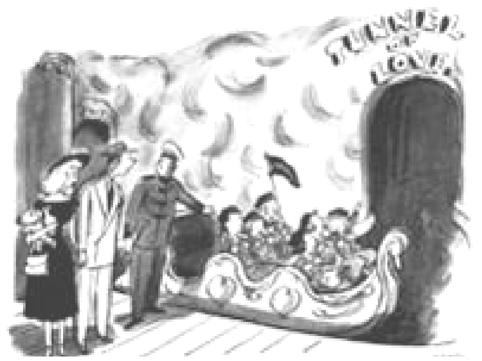
There are scores of cartoons about this underground river, far more, in fact, than unique ideas. Here are just a few.


Tunnel of Tough Love
I care about you, Ted, but it's over. Let's just shake hands and get on with our lives

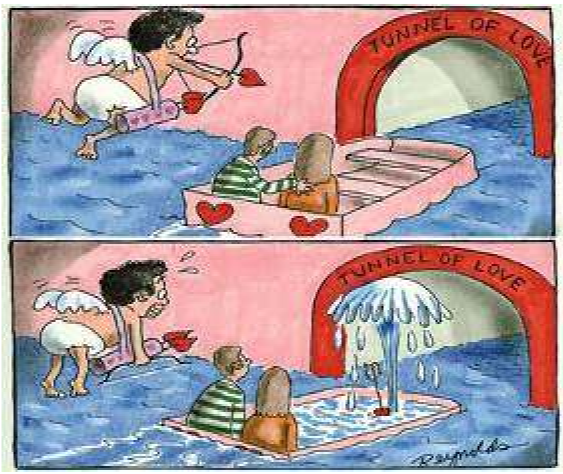

TUNNEL OF BROTHERLY LOVE

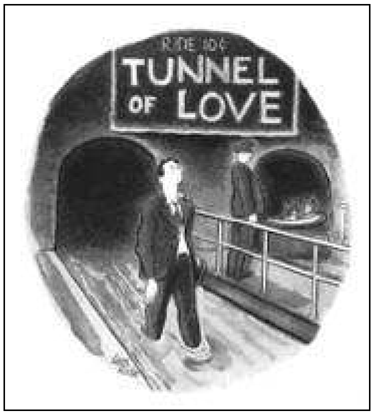

Tunnel of Love
BE PREPARED FOR ACCIDENTS

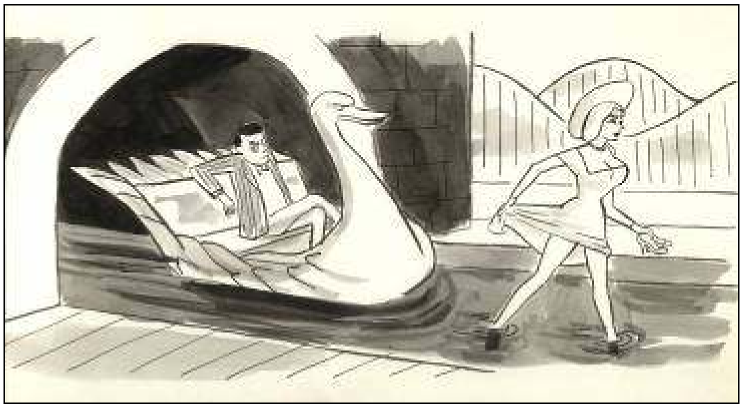

Tunnel of Like

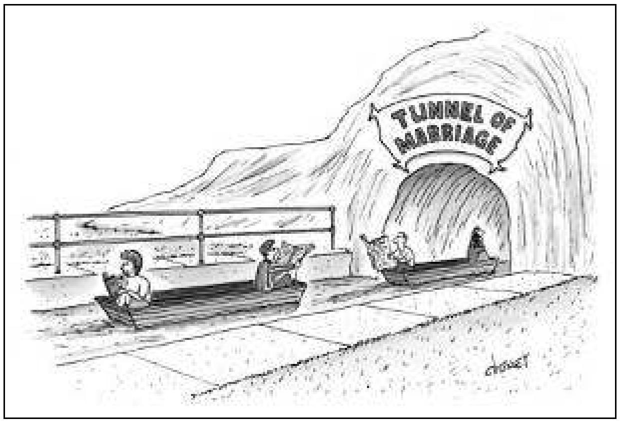

TUNNEL OF LOVE

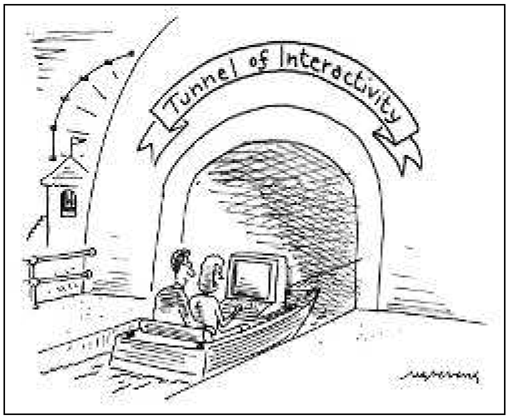
"Er---we'll wait for the next one, thanks."

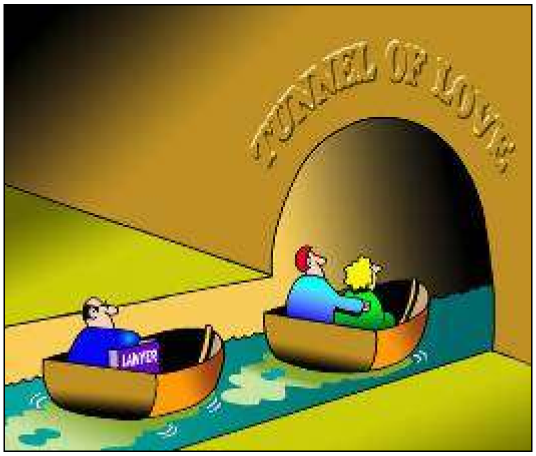

TUNNEL OF LOVE
TUNNEL OF LOVE
Reynolds

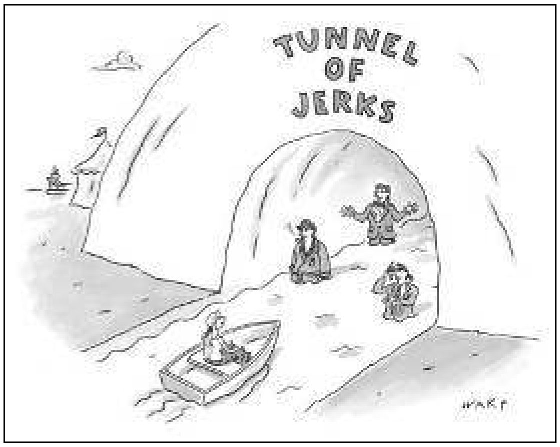

RIDE 10¢
TUNNEL OF LOVE

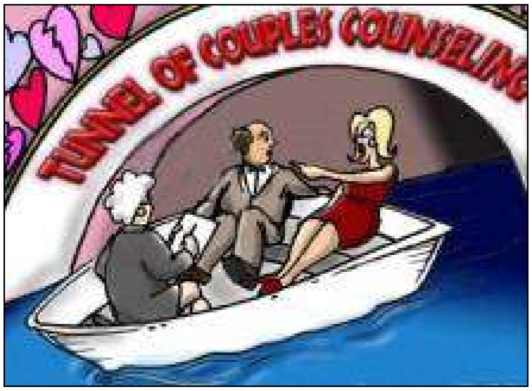


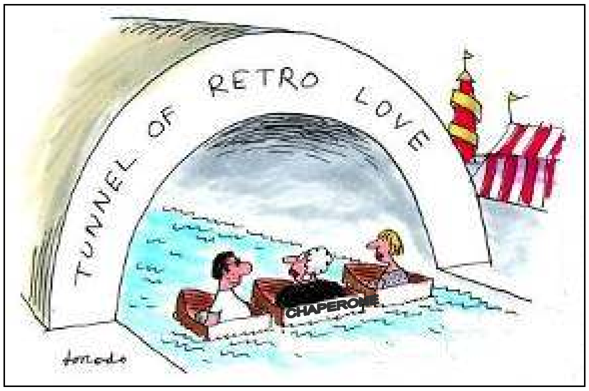

TUNNEL OF MARRIAGE

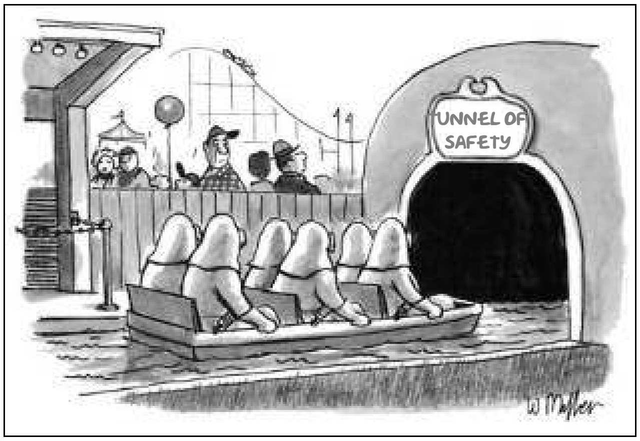

Tunnel of Interactivity

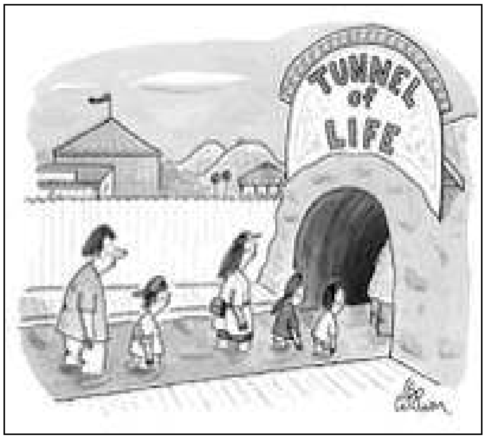

TUNNEL OF LOVE
LAWYER

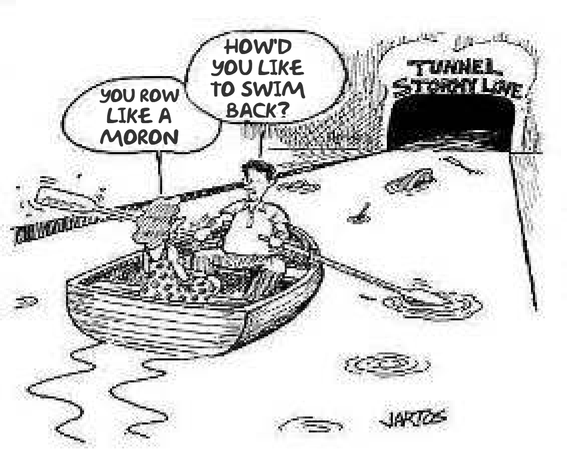

TUNNEL OF JERKS

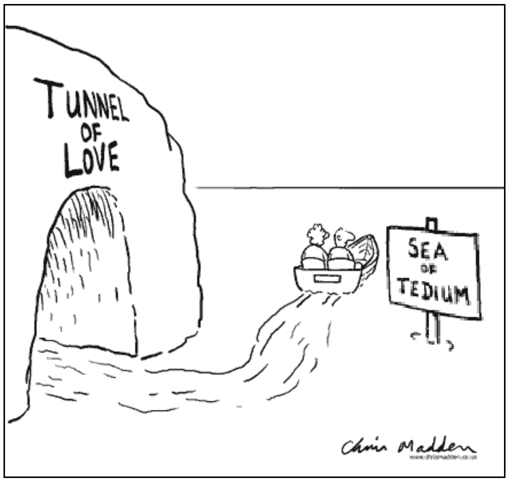

TUNNEL OF COUPLES COUNSELING

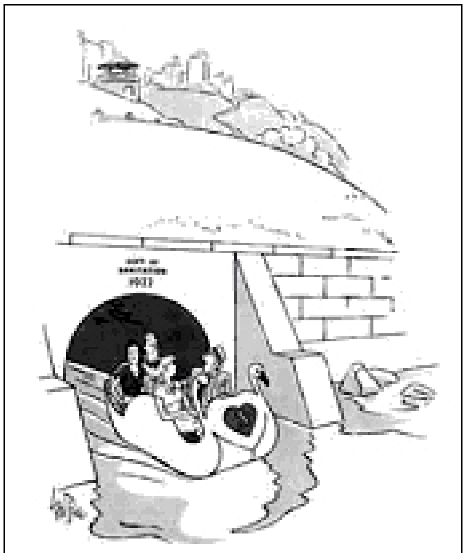

TUNNEL OF RETRO LOVE
CHAPERONE


UNNEL OF SAFETY

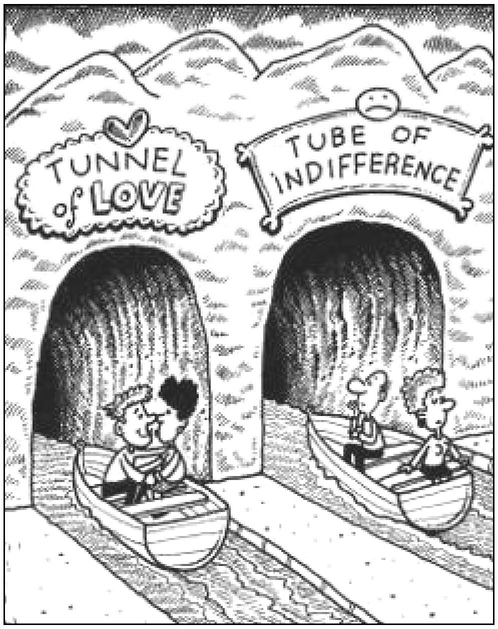

TUNNEL of LIFE

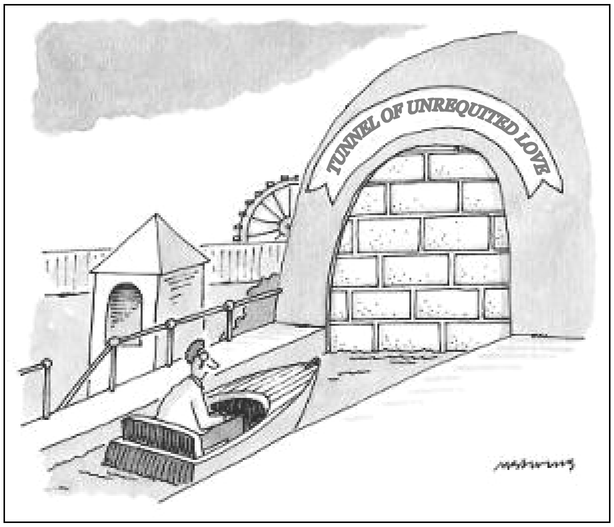

YOU ROW LIKE A MORON
HOW'D YOU LIKE TO SWIM BACK?
TUNNEL STORMY LOVE
JARTOS

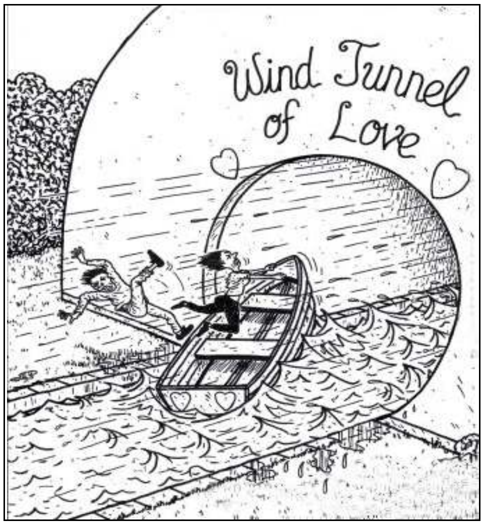

TUNNEL OF LOVE
SEA OF TEDIUM
Chris Madden

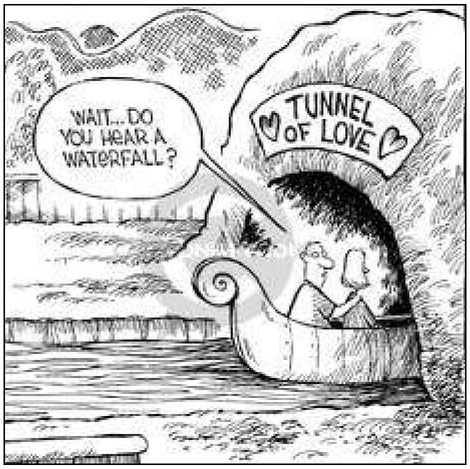


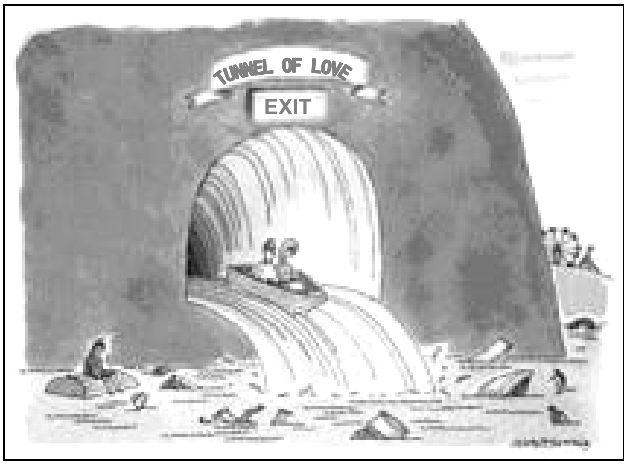
"We must have made a wrong turn somewhere."


TUNNEL of LOVE
TUBE OF INDIFFERENCE

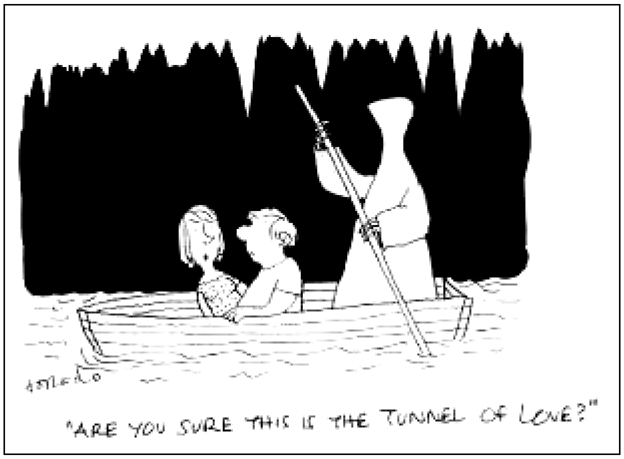

TUNNEL OF UNREQUITED LOVE


Wind Tunnel of Love


WAIT...DO YOU HEAR A WATERFALL?
TUNNEL OF LOVE


TUNNEL OF LOVE
EXIT

Compilation of cartoons brings to mind the theme of Chapter 7, The Concept of Circulation, and we're thus not surprised to once again encounter the still-laboring Charon.


"ARE YOU SURE THIS IS THE TUNNEL OF LOVE?"

Cartoons of underground rivers, like the primeval river itself and the aged boatman toiling upon it, seem likely to be long with us.

CHAPTER 61

DAMMING UNDERGROUND RIVERS

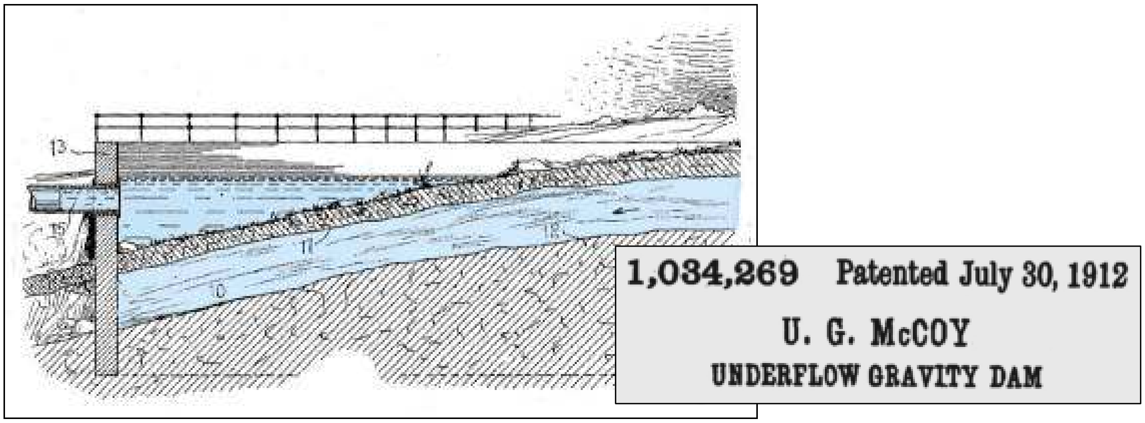
We, as human beings, endeavor to make the earth a more useful place. Surely, then, we can improve on the waterways below.

This chapter deals with the damming of natural subterranean conduits. The chapter to follow considers our other efforts.

Conduit	Dammed	Undammed
Natural	This Chapter	Following Chapter
Tunneled		

United States

We begin with a pair of United States patents.

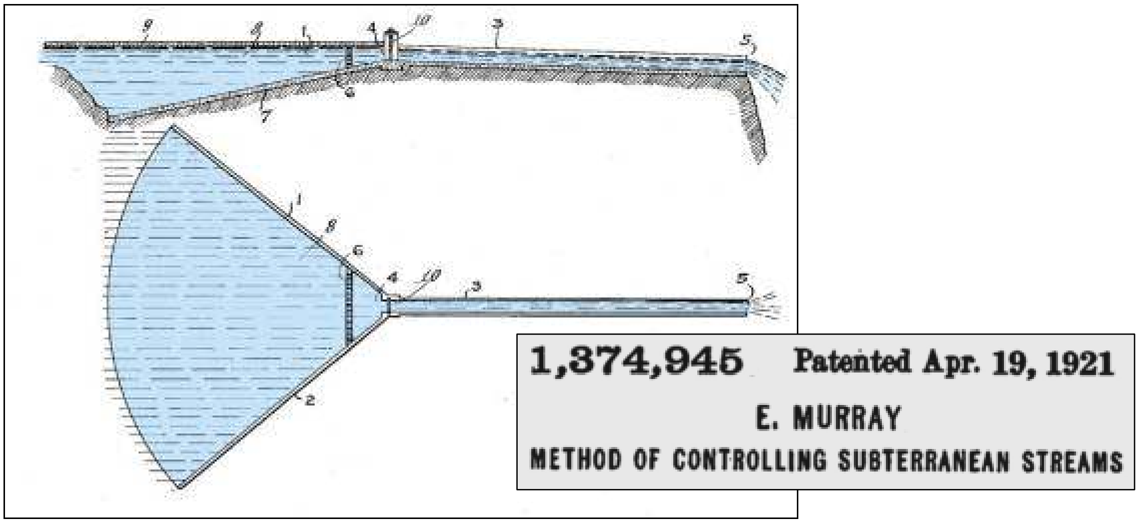


1,034,269 Patented July 30, 1912

U. G. McCOY

UNDERFLOW GRAVITY DAM

A dam for underground waters consisting of a V-shaped structure sunk in the earth a sufficient distance to intercept an underground stream.



1,374,945 Patented Apr. 19, 1921

E. MURRAY

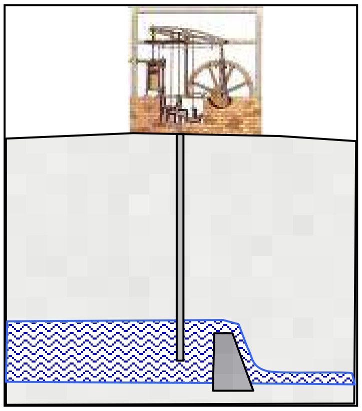
METHOD OF CONTROLLING SUBTERRANEAN STREAMS

It is well known that subterranean streams generally flow incessantly and it is generally estimated that there is a drop of at least seven feet to the mile. It is, therefore, obvious that if

> *the power of such stream could be utilized for industrial or commercial purposes, a very valuable adjunct to the industrial development of a community would be provided.*

It turns out, however, that underground rivers were dammed before the patents. A "young man from the East" merited mention in "An Underground Water Supply; a Subterranean River Tapped for the City of Galveston's Uses," New York Times, April 15, 1893.

> *Gainesville, Texas, April 14 -- One of the most remarkable systems or water supply in the world is to be found in this city. About a mile north of the city is a valley a thousand feet wide, which surveyors determined to be the location or an underground stream, though the valley itself was dry and under cultivation.*
>
> *It was suggested that he wells might tap this stream and give the city a pure supple of water. The City Engineer, a young man from the East, suggested that, in lieu of a reservoir, the hidden stream be dammed, when there would be at all times be an inexhaustible supply*
>
> *Sinking a large one in the center of the valley, he struck living water at the depth of 30 feet, coming in such quantities that a powerful steam pump could not lower it to any perceptible degree. An appropriation enabled him to carry out his plan, which resulted in obtaining an unlimited quantity of pure water.*
>
> *Sinking five wells, 200 feet apart, he covered the entire width of the stream. He next tunneled from well to well, making six-foot excavation the entire distance across the stream. This was enlarged so as to be 6 feet high and 8 feet wide. Then on the lower side he built a substantial stone dam 6 feet high, its foundation being below the bed of the submerged stream, which was clearly defined. The water collected so fast that the central section had to be left until the two wings were completed. When this was done the work was begun on the central unfinished portion, two powerful steam pumps being required day and night to keep down the water so that workmen could complete the structure.*
>
> *Soundings showed that before the connections were made with the mains leading into the city the tunnel was filled with water, and a current flowing over the dam was observed as all five of the wells. The mains were filled as soon as the pumps could be set at work, and although no limit has ever been placed upon the use of the water, the supply has never at any time been lowered below the top of the dam. In rainy weather and in dry weather the volume of water has remained the same. It is free from all vegetable and mineral impurities and is cool and sweet.*



CERTIFICATE OF DEPOSIT

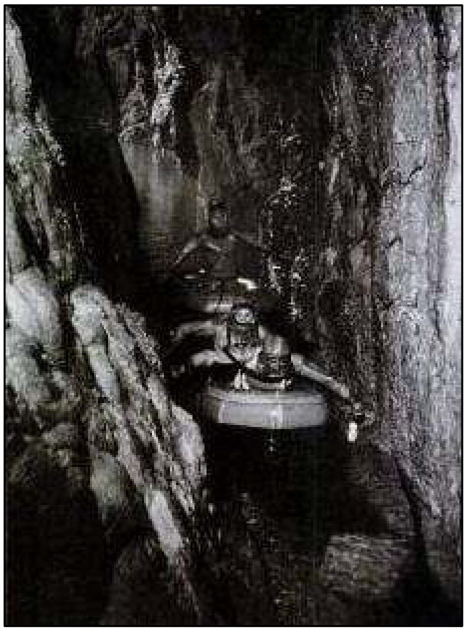
Gainesville Water Company of Gainesville, Texas

No. 9 $1,000

OCT 27 1909

By its location, the 1893 project tapped the Gulf Coast aquifer, a broad sandy stratum 70-150 meters in thickness, not, as favored by journalists of the era, a "hidden stream."

Modern Galveston derives less than 10 percent of its water from the ground, and even at that limited pumping, the water table has dropped more than 100 meters in some locations. The promised "unlimited quantity of pure water" wasn't to be.



France

"Into the Earth Once Again. River Traced, Cascade Found," Life, October 26, 1953, describes the exploration of the caves at Pierre St. Martin in the Pyrenees.

> *Kakaueta Gorge, on surface outside caves, is explored by rubber boat. Explorers found dye put in underground river emerged here, on French soil.*

"Explorers Dispute New Cave Mark," Schenectady Gazette, August 20, 1953, dwelt on claims regarding the cave's depth.

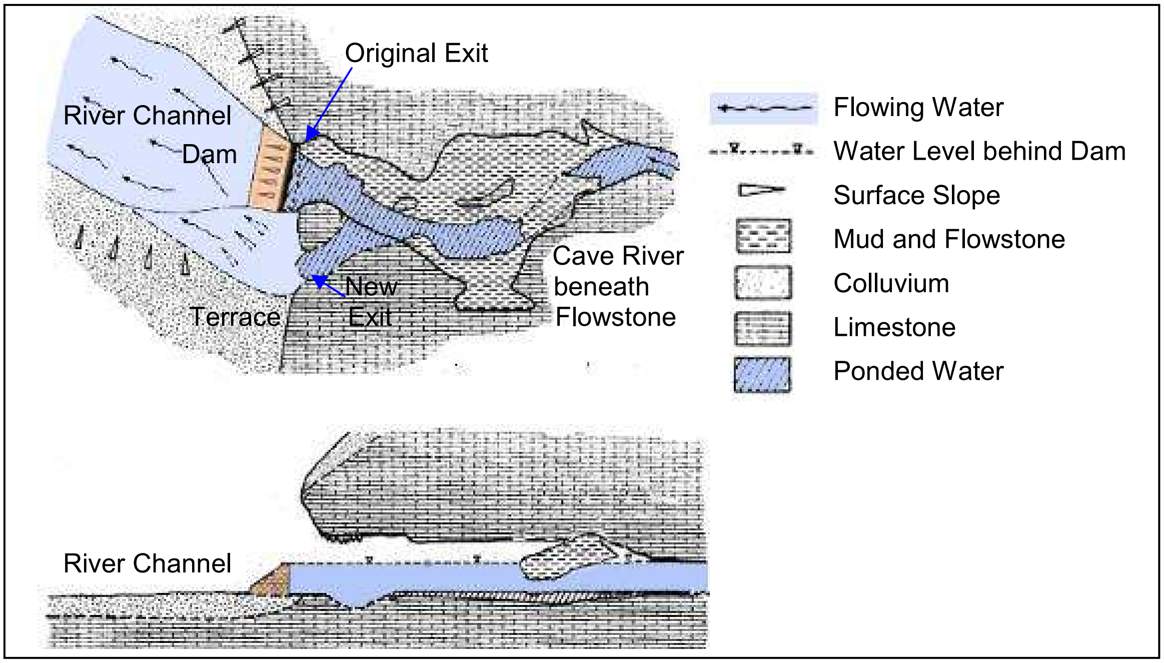
> *All of the team agreed, however, that they had discovered several new underground galleries and a vast underground cavern.*
>
> *They made no comment on whether an underground river discovered last year would possibly be harnessed for electric power.*

Water 700 meters beneath the surface is an unlikely hydropower source, but cave explorers tend to be bold in ambition.

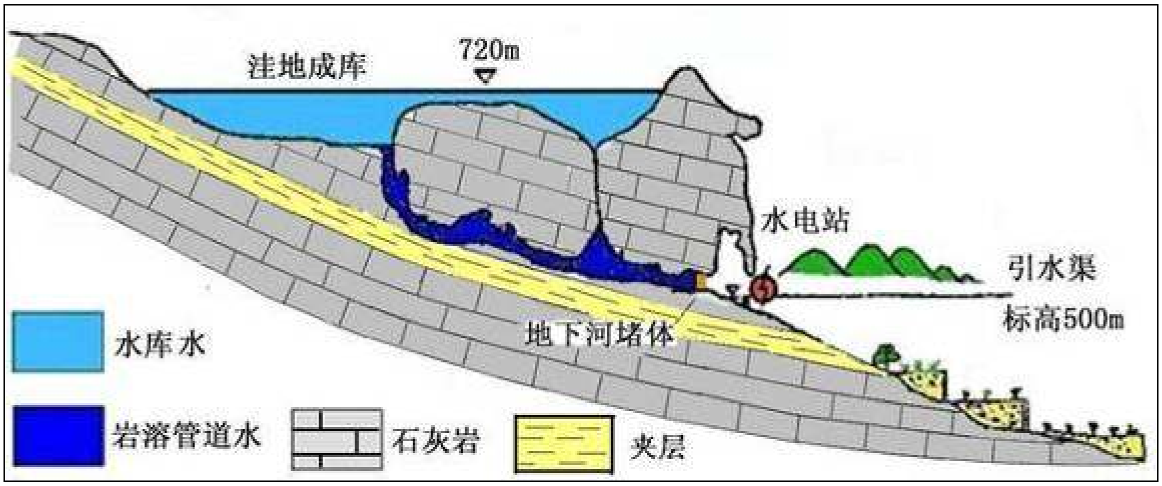
China

With its karst terrain and growing energy needs, China is ambitiously pursuing subterranean hydropower projects.

In the Guanyan karst of Guangxi Province, five sites have been developed for the installation of dams: four underground and one, shown below, at the Xiaoheli Yan resurgence.

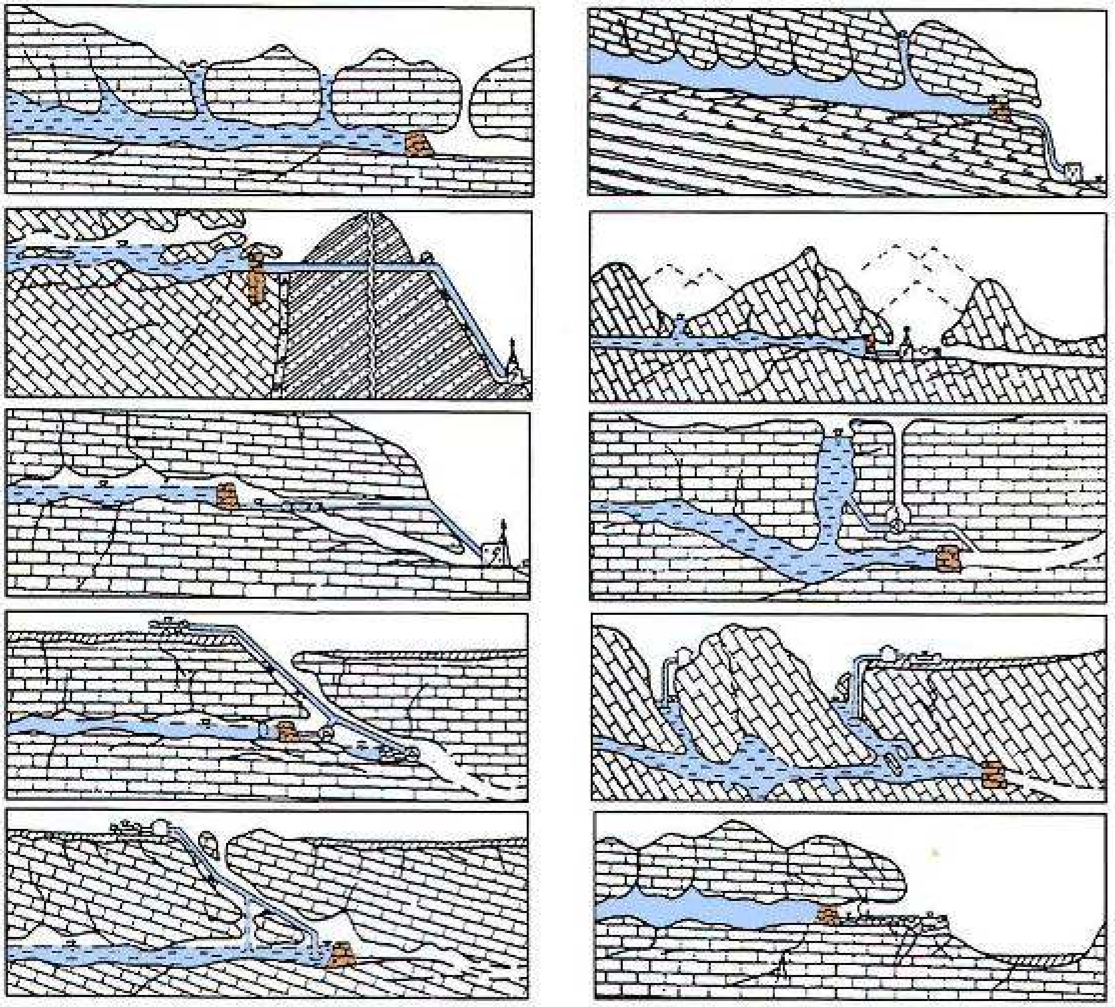

Original Exit
River Channel
Dam
Terrace
New Exit
Cave River beneath Flowstone
Flowing Water
Water Level behind Dam
Surface Slope
Mud and Flowstone
Colluvium
Limestone
Ponded Water
River Channel

"Geologic Survey on Groundwater and Environment in Southwest China Karst" (2011), Institute of Karst Geology, Chinese Academy of Geological Sciences, suggests building a cave dam to seal an entire karst outlet, causing water to back up into the higher tiankengs (Chapter 40, Sinkholes).

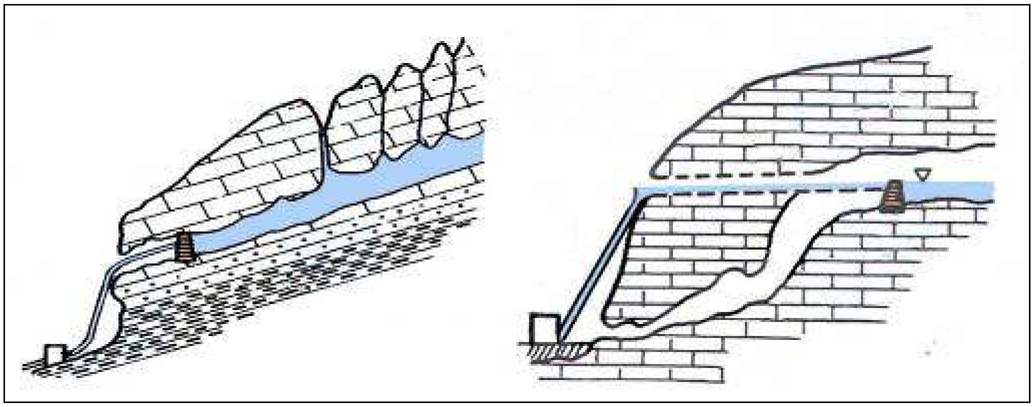


Practicality, however, poses challenges, as karst formations are characterized by interlaced conduits and blocked water would find another way out.

The sections below, taken from Some Problems of Subsurface Reservoirs Constructed in Karst Regions of China (1986) by Y. Lu, illustrate a variety of possibilities.



From the same publication,

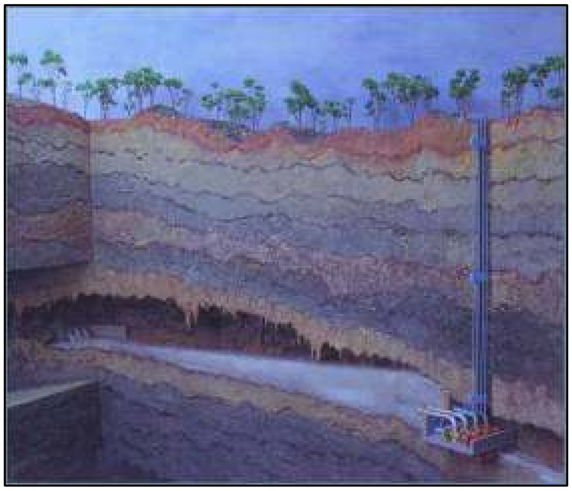


Two Chinese Karst Hydropower Plants: Yohong and Beilou

Indonesia

In "Survey in a Water Resource Management Project of an Underground River in Indonesia," Boletim de Ciencias Geodesicas 12:1, January 2006, Günter Schmitt and Martin Vetter revive the idea of underground dams also noted in Chapter 59.5. The proposed project makes use of a 3.5 kilometer channel 100 meters beneath the surface.

> *The installation of an underground water reservoir is aspired, using appropriate technologies and regenerative energies. The intention is to use the underground water resources by partially damming up the water flow by means of a barrage with an integrated micro hydro power plant. A feasibility study supported by the Federal Ministry of Education and Research found the cave Gua Bribin in the region of Wonosari as suitable for a pilot project. The cave guarantees a storage volume of roughly 400,000 m3 with a minimal available flow of 2000 l/s during the dry season and a potential water height after damming of about 15 m.*



The project will include,

> *Partial damming of the water flow system by a reinforced concrete dam with an integrated micro hydroelectric power plant,*
> *Energy production for water supply through the construction of a weir and pressure pipeline,*
> *Energy production for water supply through a cascade of weir systems with open channel flow.*

The system would provide enough power to provide 75,000 humans with 80 liters of potable water/capita/day.

Hollywood

An electrical question about which we've wondered: How in Bela Lugosi's 1943 Frankenstein Meets the Wolf Man were the frightening capacitors charged?

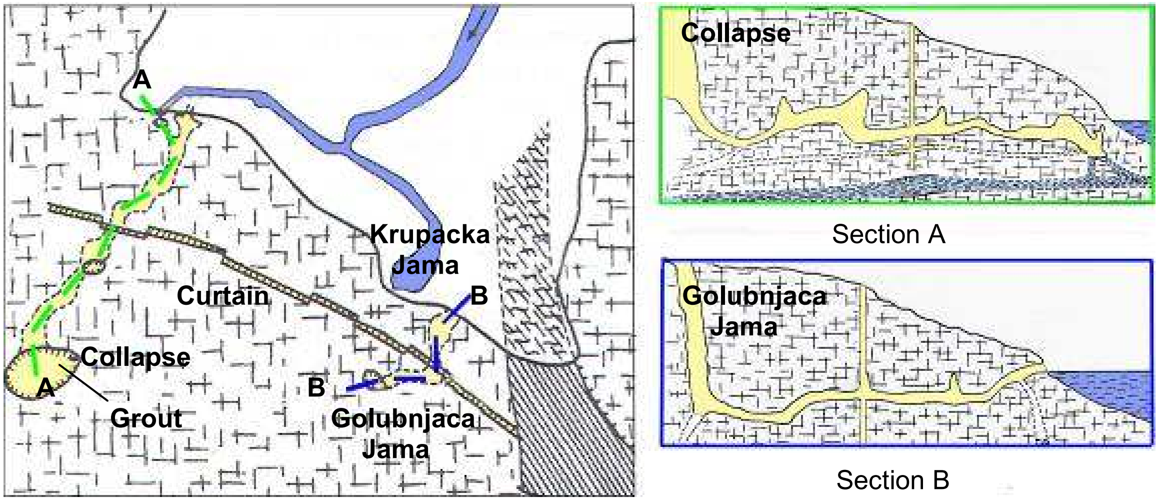
The answer's in the dialog,

> *Here runs the underground stream that drives the turbines that Frankenstein installed*.

Grouting

Grouting, the injection of an impermeable sealer into the voids of an otherwise-porous media, has long been used to seal underground channels.

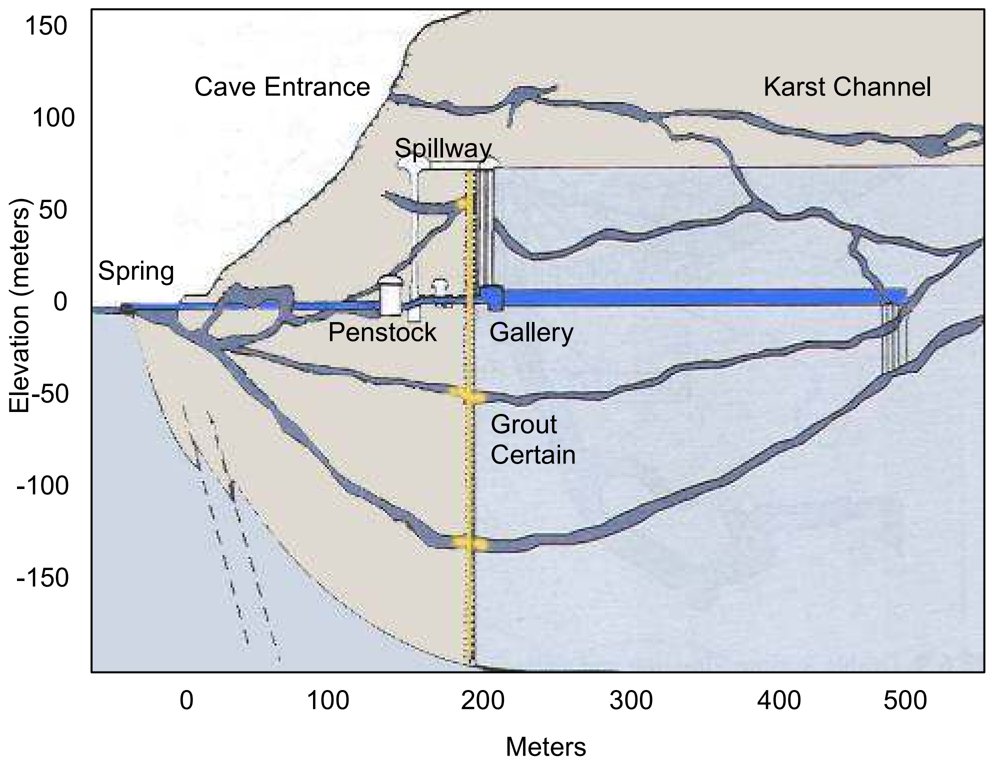
Karst sinkholes causing as much as 4 cubic meters/second of leakage from Montenegro's Krupac Reservoir were grouted in the late 1950s. The diagram shows the two-pronged approach: curtaining the full width of the leaky limestone and directly filling the accessible chambers.



Plugging of the Krupac Sinkholes

One borehole received 750 cubic meters of crushed stone plus sawdust and admixture (70 percent sand, 30 percent cement). Grouting increased the reservoir capacity by 20 million cubic meters. We'll have more to say about Balkan karst in Chapter 72.

Croatia's Ombla River (Chapter 72, Underground and Balkanized) is proposed for a 68-megawatt power plant and a grouted underground reservoir flooding the cavern system to just below the cave entrance.



Sand Dams

Sand dams are buried dams designed to retain water in the interstices of sand and gravel on the upstream side. Sand dams are generally situated to cross the bed of a river which on the surface may be seasonally dry, but continues to transmit water through the porous bed material.

As sand dams are for the "underground damming of rivers," as opposed to "damming of underground rivers," and thus perhaps fall somewhat outside the purview of our study, but we include them in our chapter because the public may not always catch the distinction.

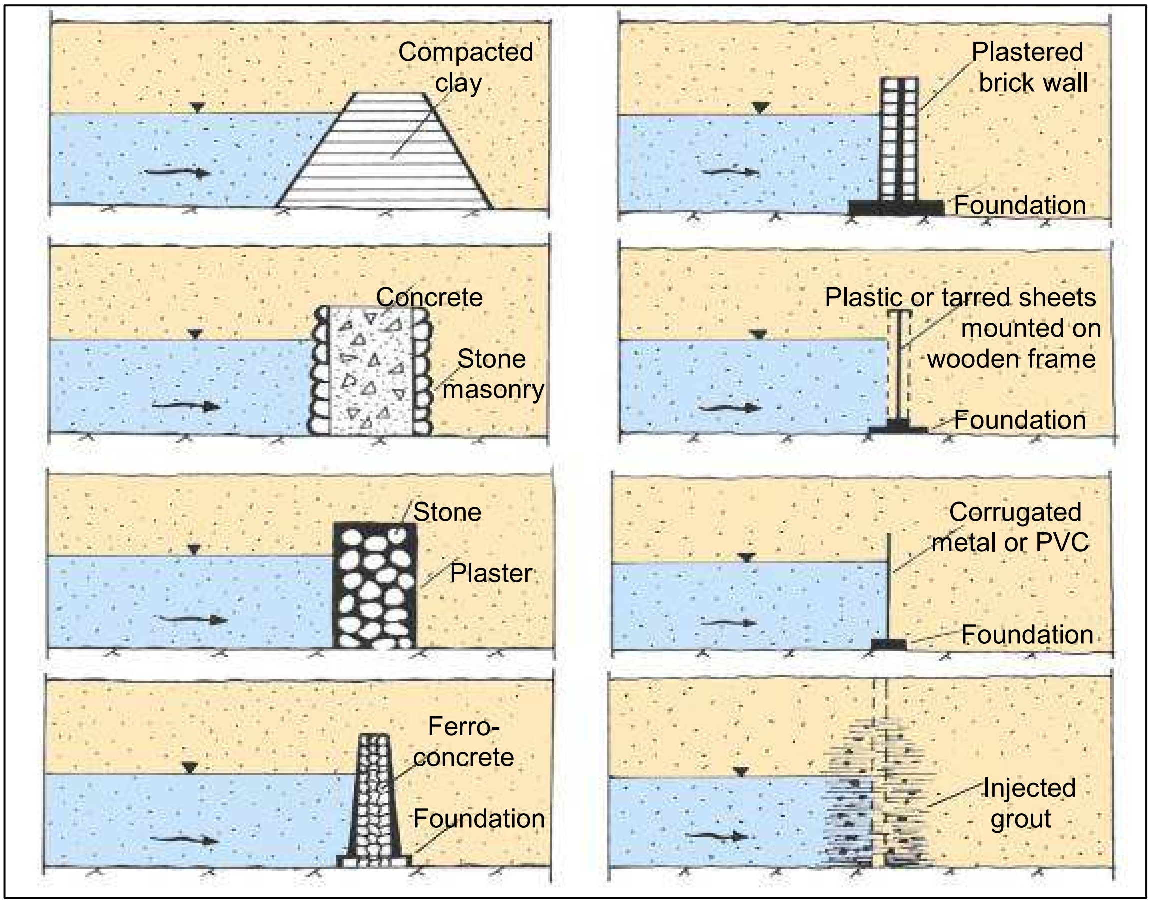
For a sand dam to be effective, it must extend to a less-permeable substrata to prevent the flow from seeping under the structure. Water is most often extracted by shallow wells. A sand dam ceases to function if silt washes in and fills the voids between the sand particles.

At best, a sand dam provides room for only a fraction of the water that would be held in a topographically-comparable surface reservoir, but the water behind a sand dam is slower to evaporate. The passive pressure of river bed material on a sand dam's downstream face provides it structural stability. Unlike catastrophic concerns associated with possible failure of a surface dam, if a sand dam leaks a bit, it's not likely structurally compromised.

The field tests below are from Rain Catchment and Water Supply in Rural Africa: A Manual (1982), by Erik Niessen-Petersen.

Material	Silt	Fine sand	Medium sand	Coarse sand	Fine gravel	Gravel
Size (mm)	<0.5	0.5-1	1-5	5-19	5-19	19-70
Porosity	0.38	0.39	0.41	0.45	0.47	0.51
Extractability	0.05	0.19	0.25	0.35	0.41	0.50

Below are several sand dam construction possibilities, all but the last requiring excavation.

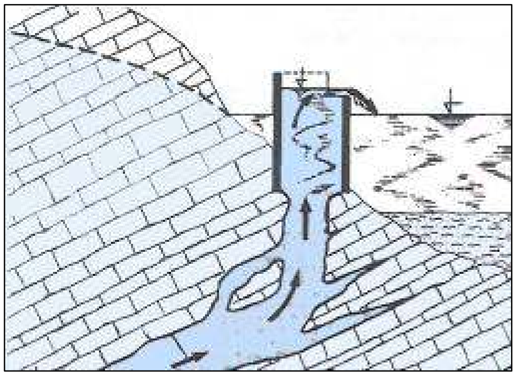

Compacted clay
Plastered brick wall
Foundation
Concrete
Stone masonry
Plastic or tarred sheets mounted on wooden frame
Foundation
Stone
Plaster
Corrugated metal or PVC
Foundation
Ferro-concrete
Foundation
Injected grout

Kenya

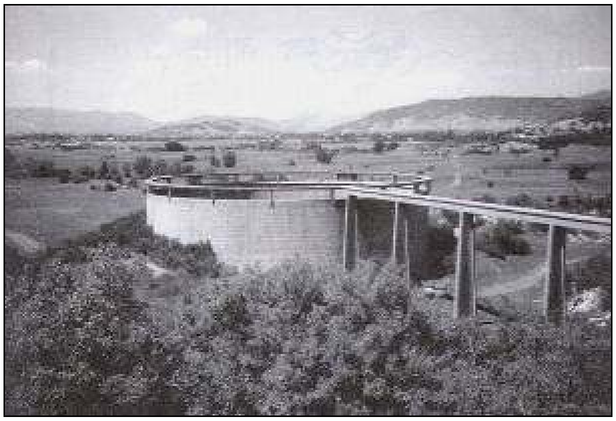
Northeast Brazil

Artesian Springs

Although here we're talking not about a dam under the ground, but rather about damming the outflow from an underground channel, we'll add to our survey the option of containing an artesian upwelling (Chapter 38, Hydrogeology).



Below, cylindrical dams around Opacica and Slivlje Springs, both in Montenegro



Conclusion

If God didn't wish us to dam underground rivers, we might argue, He'd have put them further beneath the surface.

CHAPTER 62

MORE HYDROPOWER FROM THE DEEP

This chapter deals with subterranean hydropower derived from tunneled conduits and from undammed natural channels.

Tunneled Penstocks

When turbines replaced waterwheels in the late 19th century, pressurized penstocks replaced mill streams. Most penstocks are located within dam structures, however, not "underground." We'll count, however, tunnels for hydropower hewn through the earth.

In 1858 the New York State Legislature authorized the Lockport mill race to be converted into a tunnel for industrial hydropower. Blasting through solid rock produced a head of 17.4 meters and 180 kilowatts.

Subsequent reconstruction

Lockport Cave, now part of the Erie Canal National Heritage Corridor, features a cave boat tour focusing on artifacts left by the miners.

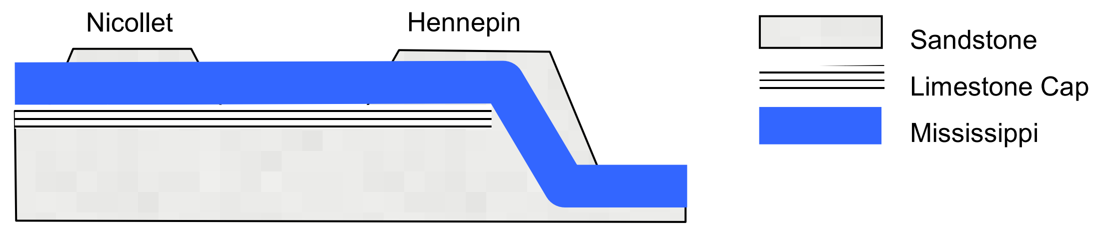
American Record

Longest Underground River Boat Ride

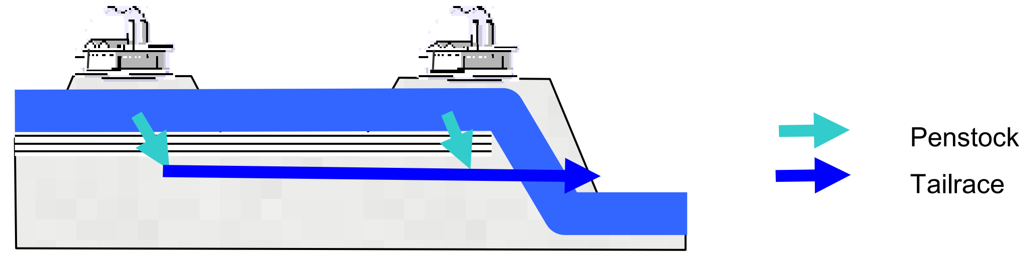
Lockport
$11.50

St. Anthony Falls in Minnesota is the Mississippi's only true waterfall, the consequence of a limestone cap perched over softer sandstone. An 1852 photo is to the right.

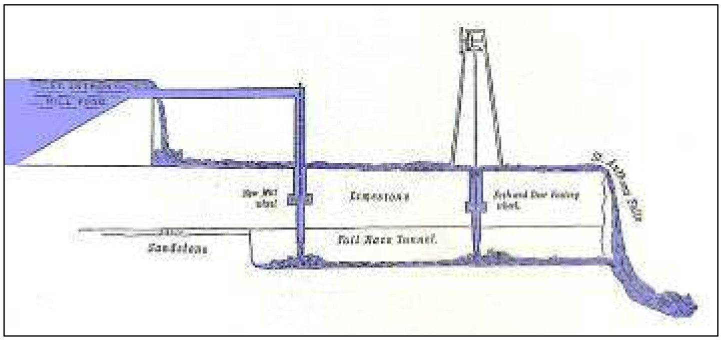
In 1867, industrialist William Eastman gained control over a portion of Nicollet Island above the falls and Hennepin Island at the falls, and began construction of a 760-meter, 2 by 2 meter hydropower tailrace from Hennepin and under Nicollet. The plan amounted to diverting a small portion the Mississippi underground.


Nicollet
Hennepin
Sandstone
Limestone Cap
Mississippi

What Mother Nature Provided

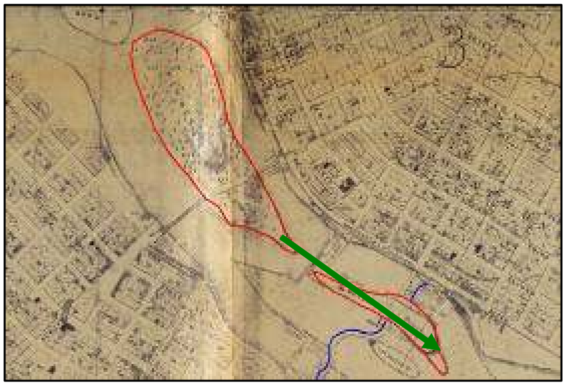

Penstock
Tailrace

What Mr. Eastman Wanted

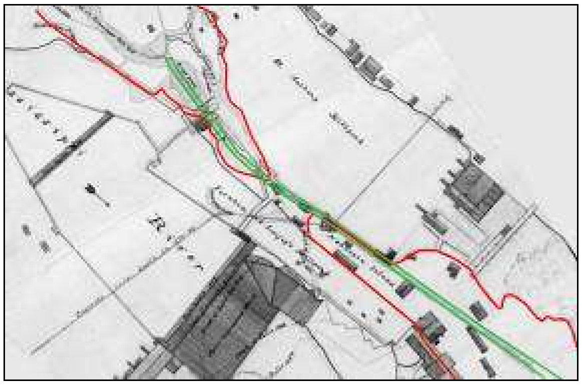

Limestone
Tail Race Tunnel.
Sandstone
St. Anthony Falls

From Report on the Water-Power of the Mississippi River and Some of its Tributaries (1887), Tenth Census of the United States, 1880, J.L Greenleaf,

The maps below show the layout, first as an overlay on an earlier city map and the second, a post-project layout showing the industries. Nicollet and Hennepin Islands are outlined in red, Nicollet being the upper. St. Anthony Falls is marked in blue and the tunnel is in green. Note that the tunnel runs below the riverbed (and thus the limestone cap) between the islands.



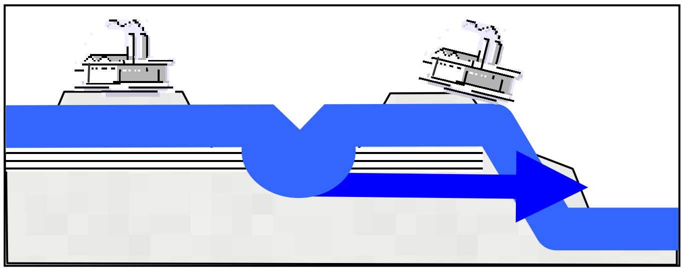
R&F Cook Map (1861)



Corps of Engineers Map (c. 1879)

On October 4, 1869, however, as digging neared completion, Eastman's tunnel became more of an underground river than the capitalist anticipated.

A fracture in the sandstone near the southern tip of Nicollet Island opened an upward passage to the bed of the river. The leak turned into a torrent, quickly scoured the tailrace to a width of as much as 30 meters under Hennepin Island which began to unravel at the outlet. The falls themselves were in danger of collapsing.



What Mr. Eastman Achieved

The October 7 Chicago Tribune reported the calamity.

> *The Tunnel Disaster at the Falls of St. Anthony -- The River Fast Cutting out a New Channel*
>
> *A portion of Hennepin Island, on which is situated a large number of mills and factories, has been washed away, and the break in the channel has not been repaired. The entire island is in danger... Two hundred feet of tunnel have already caved in, and unless the action of the water is checked, Minneapolis men fear the foundation of a new channel, which will destroy the water power, by conducting water away from the wheels of the mills, leaving them high and dry.*
>
> *Monday morning, the eastern tunnel, half a mile long, being excavated for the purpose of making water power on Nicollet Island, pierced a sunken water cavern in the island below the river. The gates at the head of the tunnel were closed, but the rush of the water could not be arrested. Early Tuesday morning a large whirlpool near the shore of the island was discovered, disclosing the mouth of the cavern. All efforts yesterday to close up the hole by rafts, cribs, trees, balls of hay, etc., proved fruitless and the river is making a tremendous effort to cut a new channel for relief. The mills of Hennepin Island are in danger, as the ground is caving in from the passage of the water from beneath. A thousand men are at work, night and day, constructing a coffer dam round the mouth of the whirlpool.*

> *The volume of the water rushing into the cavity has been somewhat checked by trees and sandbags... The hole is sixty feet long and twenty broad; depth not known.*

According to a local newspaper, the whirlpool in the Mississippi "tossed huge logs as though they were mere whittlings," standing them on end "as if in sport."

The Chicago Tribune of October 30, 1869, reported some success.

> *One of the new dams of St. Anthony Falls was completed to-day, so that the water can be cut off from the head of the broken tunnel, and the full extend of the break ascertained... An examination of the tunnel at Minneapolis shows the last break to be seventy feet in diameter.*

But the limestone shelf now having been compromised, fixes tended to be temporary. From the Chicago Tribune, January 24, 1870,

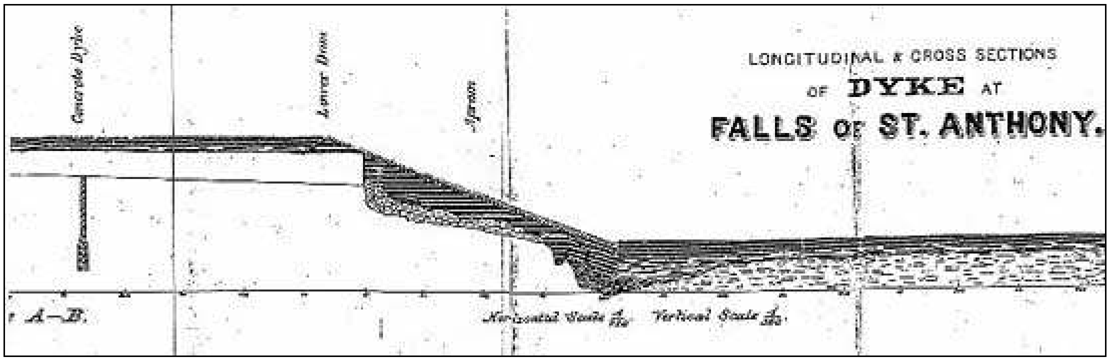
> *The proprietor of the Nicollet Island Tunnel near Minneapolis, in company with two friends, lately entered the tunnel in a boat, and had penetrated bout 500 feet from the entrance, when the awful silence of the vault was broken by the continuous crashing fall of masses of the limestone rock which form the roof. Though large fragments struck all about the boat, all the gentlemen were lucky enough to escape unhurt.*

And the situation continued to degenerate. From the Chicago Tribune, April 2, 1870,

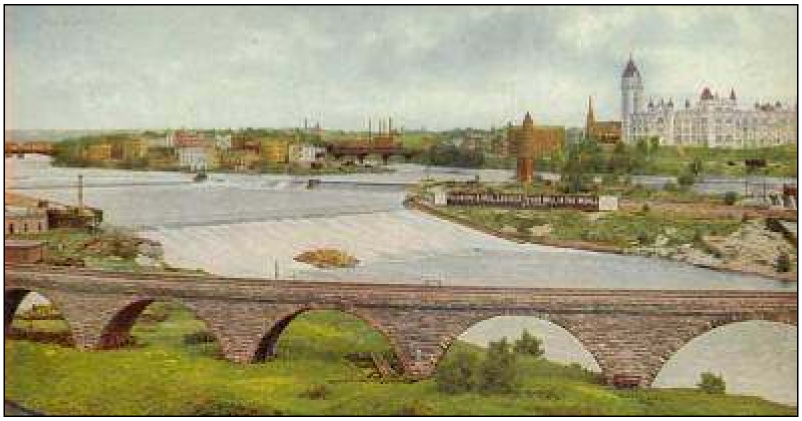
> *Another break feared in the tunnel at St. Anthony Falls.*
>
> *A portion of the filling yesterday sank, and it is reported that the rock has broken away from the bottom of the tunnel, through the sane beneath, which, if true, will render it almost impossible to prevent the water from washing away the support of the rocky crust of walls themselves.*

A July 1871 leak originating to the east of Nicollet Island and scoured a new cavity 5 meters wide, 3 meters beneath the limestone. As a result of a similar incident in August, the limestone ledge was resurveyed and found to be riddled with holes. An April 1873 flood destroyed a coffer dam to the west of Nicollet Island, opening a 50-meter gap and again flooding the tunnel.

It took shore-to-shore walls to sub-grade depth, shown below in the 1883 design, to regain control of the river.



Eastman's tunnel, the instigator of the troubles, was backfilled in 1884.



Underground River Plugged and the Mills Saved

Today, the University of Minnesota's St. Anthony Falls Hydraulic Laboratory is located on Hennepin Island. From the lab basement, one can still access the tunnel's lower portion

From Greg Brick's Subterranean Twin Cities (2009),

> *Descending through the trapdoor under the lab, I found that the Eastman Tunnel ran under the riverbed as far as my light beam went; I hoped to be able to get all the way up under the dam itself. At one point I peeked up through a grating into the Main Street Power Station, observing the dynamos with wonder. The going soon got rough. When the mud got waist deep, I was ready to turn back, but I could see the end of the tunnel, so I persevered. Finally, I arrived at the concrete bulkhead, a total distance of one hundred feet from the walkway.*

Eastman's tunnel might have provided underground hydropower, had not the Mississippi acted like the Mississippi.

Let's move to modern times and look at the "Underground River Micro Hydropower Plant" enabled by the construction of a wastewater tunnel under Lausanne, Switzerland. Laid in an existing riverbed having a 180-meter drop, the tunnel is sufficient for both the wastewater and the natural streamflow, the former on the tunnel floor and the latter via a 120 liters/second pipe to a 185-kW Pelton wheel. The inlet is shown below.

It's conventional hydropower technology, but as the pipe is in some sense "underground," we must allow the deceitful claim.

Hydropower from Qanats

We discussed qanats in Chapter 59, Subterranean Aqueducts. M.L. Khaneiki and A.A.S. Yazdi advocate their hydropower potential in "Extracting Electricity from Groundwater Flow; A New Environment Friendly Source of Energy Case Study: Iran," Eighth EEEIC International Conference on Environment and Electrical Engineering, Karpacz, May 2009.

> *First a shaft well is sunk from the bottom of which a tunnel is dug up... This shaft well can be drop tower for a watermill underground where the build up of water in the well can provide adequate water pressure to rotate the millstone. At the bottom of the well, a small hole is made such that water can spout out of it and hit the rotor blades of the watermill. Thus the rotor blades would run and the movement would be imparted to the upper millstone by a shaft which passes though a hole in the lower millstone and then turns the upper one horizontally...*
>
>
>
> *Nowadays this technology has been abolished, because wheat is subsidized and purchased by the government, and is ground in big factories. So the villagers no longer need the underground watermills to grind wheat. Nevertheless the idea of this paper -- generating electricity -- was inspired by the abandoned watermills, and we place turbine on the way of groundwater though this time its product is electricity not flour...*
>
> *We conducted a study in the province of Yazd in Iran on the potential that the qanats have to generate electricity. In this area some 3200 qanats are running, most of which enjoy a head less than 8 meters, so it seems that the suitable turbines for these qanats are Francis, Kaplan and the propeller turbines... In case we take the minimum electricity to be some 400 watts just to provide power needed for light and ventilation in the qanat itself, the qanats with low discharge require a head of 10 meters, which can not be found in Yazd. But in terms of the qanats with relatively high discharge and low head, the turbines of Powerpal and Nautilus seem suitable.*
>
> *In closing we can conclude that:*
>
> 1. *The maximum electricity extracted from such turbines is 1 kilowatt, but considering the length of qanats which is tens of kilometers it is quite possible to install a series of turbines along the tunnel to get more electricity.*
> 2. *Those qanats whose discharge is below 45 liters per second do not meet the requirements of this project, because this project is in line with the product of net head multiplied by discharge, so in case of lower discharge we need higher head which can not be higher than 8 meters considering the structural condition of the qanats in Yazd.*
>
> *Due to these requirements, out of 3200 qanats in the province of Yazd, 100 qanats whose discharge is over 45 liters per second providing appropriate head have been singled out. Each of these 100 qanats can house one or several turbines, such that the total electricity generated by them would amount to thousands of kilowatts*

As with this study ant those to follow, however, we're provided neither economic justification nor suggestions regarding maintenance.

Hydropower from Subterranean Pumped Storage

Pumped storage isn't a generator of hydropower, per se, but it's a way to bank such energy for times of high demand.

Frank Winde and E.J. Stoch propose a groundwater scheme for pumped storage in "Threats and Opportunities for Post-Closure Development in Dolomitic Gold-Mining Areas of the West Rand and Far West Rand (South Africa) – a Hydraulic View -- Part 2, Opportunities," Water SA 36:1, January 2010.

> *The basic principle of underground hydropower generation is based on utilizing elevation differences between adjacent compartments and associated karst cavities in much the same way that the ESKOM pumping scheme at the Sterkfontein Dam in the Drakensberg works, i.e., driving turbines which generate electricity in peak demand times (daytime) and pumping the water back to the upper reservoir at cheaper night-time tariffs. A similar system is currently installed in karst areas of Indonesia, where underground flow drives irrigation pumps bringing the water back to the surface at minimal pumping costs. With deep shafts and large voids created by mining, this technology may be able to utilize not only karst voids and natural gradients but also some of the underground infrastructure such as shafts, haulages and existing mine-water reservoirs. The Kloof Mine is reportedly already using hydropower in its underground operations and may consider a larger scale expansion. Depending on the possible implementation of active groundwater recharge and harvesting schemes mentioned above, post-flooding water levels in the dolomitic compartments could be kept at such elevations that near-surface karst cavities at different levels could be connected through existing shafts or other conduits and utilized for underground hydropower generation even after re-watering.*

Pumped storage is occasionally incorporated with surface reservoirs. In theory, it could work for reservoirs below, but it's yet to be done.

Hydropower from Spring Elevation

The phrase "to carry a mill" speaks of earlier times.

> *Subterranean Streams. The Hadley Falls Company, in excavating their new raceway, cut into a subterranean stream, large enough to carry a mill, flowing down the Connecticut, thirty or forty feet below the level of the railway*. -- Scientific American, July 15, 1848

> *There are said to be underground creeks in the limestone of Georgia with currents of sufficient velocity to carry a mill. There is a government tannery, the bulk of which is driven by one on these subterranean streams.* -- Scientific American, July 29, 1865

Such "underground" streams would have exited the earth before powering a vertical water wheel.

Clark B. Firestone, Bubbling Waters (1938) describes a mill in Mill Springs, Kentucky.

> *Fourteen springs gush from the hillside in a stretch of perhaps a hundred yards, and their waters are impounded by a stone wall in a sort of canal shaded by tulip poplars. It is something like an underground river bursting into the sunlight wherever it can force an opening. A flume leads the collected waters to an overshot wheel on the downstream side of the mill.*

"Mysterious Lost Rivers Run Mills and Power Plants," Popular Science, November 1934, describes a similar instance of "underground" hydropower.

> *In Morgan County, Alabama is a mill stream noteworthy because it is entirely underground. In a two-mouthed cave, a subterranean creek emerges in the form of a spring, and then flows sixty or seventy feet to the site of an old mill. The water was dammed up, when the mill was built, by piling rocks across the creek in the larger of the cave mouths. Thus the old mill pond is entirely subterranean.*

Dammed within the cave, the water was underground. Flowing out, however, it was just another mill stream.

We will revisit Thousand Springs on the Snake River in Chapter 86, The Rio San Buenaventura, but here we will note the hydropower of this "underground river."

From "Developing a Unique Idaho Water-Power," Electrical World, July 6, 1912,

> *Many different attempts have been made in earlier years to collect and utilize the flow from the Thousand Springs, but without success, owing to the peculiar nature of the problem, the difficulty of foundationing structures on the side of the cliff and the long contact outlet of the water. The final solution, carried out in connection with the present development, was the erection of a concrete canal wall on the side of the cliff at the outflow level. This wall is 400 ft. long and in places 16 ft. high. It forms a canal 20 ft. wide, whose other side is the native cliff and in which the water from the numerous spring outlets is collected. At one end for a distance of 150 ft. the canal is widened to 40 ft., forming a forebay opening to the penstocks which are to convey water to the power house beneath.*
>
> *The construction of this wall was especially difficult, both on account of its precarious foundationing on the side of the canyon and owing to the provisions which had to be made for the cofferdam to hold back the water from the concrete forms during building. There is no way of shutting off the flow, of course, and the water had to be deflected while the concrete was setting. Other difficulties were experienced in sealing the ends of the contact crevice to prevent the water from finding its way out of the sides. Although the present is but a partial installation, the canal wall as initially built is provided with two spillways, totaling 90 ft. in length, which is ample to discharge the entire flow from the underground river.*

Cliff-side Capture of Thousand Springs

No. 12. NEW-POWER-PLANT-

Powerhouse Construction, 1912. Note the twin spillways on the right.

The plant today has a capacity of 8,000 kilowatts.

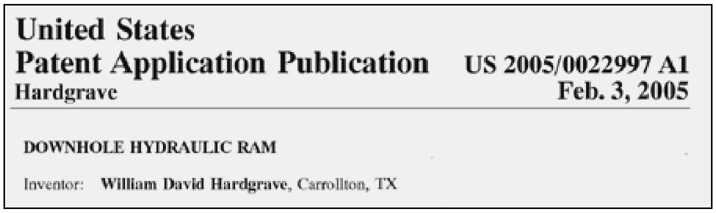
Before we leave the topic of mills, we'll quote a letter to the editor of London's General Evening Post, September 23, 1779, regarding a subterranean excursion in the Yorkshire Dales. Reference to "as much water as would turn several mills" was but for quantitative comparison, not as an industrial proposition, we're relieved to say. We like the dramatic prose.

> *But to resume our journey down this amazing cavern, after descending from ledge to ledge in retrograde motions, through arches of prodigious rocks, thrown together by the rude but awful hand of Nature, at the depth of 70 yards we see a parabolic cascade rushing from a hole nigh at the surface, and falling the whole 70 yards, with a roar, confounds and astonishes the most intrepid ear! The spray arising from this cascade fills the whole cavern, and if the sun happens to shine into it, generates the most vivid and surprising rainbow. Another cascade of not quite so great a fall issues perpendicularly from a projecting rock with equal rapidity as the first and is certainly a part of the same subterraneous brook; they fall together into a narrow pool at the bottom which measures 37 yards in depth; and projecting underground about a mile, break out and form the large brook that runs by Ingleton, and from thence to the river Lune. In the time of*

> *great rain, the subterraneous channel that conveys away the water becomes too small and then the cavern fills to the depth of above 100 yards, and runs over the surface.*
>
> *To see as much water as would turn several mills rush from a hole near 70 yards above the eye, in such a projectile as shows its subterraneous fall to be very considerable before it enters the cavern; and to see the fine skirting of wood, with various fantastic roots and shrubs, through a spray, enlivened by a perfect rainbow, so far above the eye, and yet within the earth, has something more romantic and awful in it than any thing of the kind in the three kingdoms.*

The upward view sounds like that of Fall Beck -- the latter's drop being a bit over 100 meters -- but the route doesn't seem to correspond to the Gaping Gill complex (Chapter 49, Subterranean Watercraft) as accessed in that era. Subterranean streams able to carry a mill -- or in this case, several mills -- remain forever mysterious, it seems.

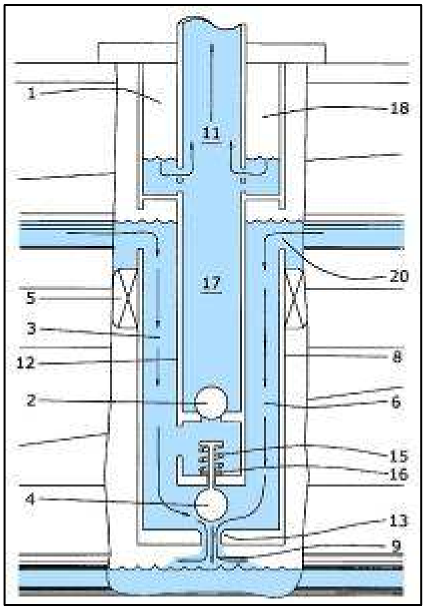
Hydropower from Subterranean Hydraulic Rams



United States
Patent Application Publication **US 2005/0022997 A1**
Hardgrave **Feb. 3, 2005**

DOWNHOLE HYDRAULIC RAM

Inventor: **William David Hardgrave**, Carrollton, TX



A hydraulic ram is a mechanical device in which energy derived from the fall of a large stream a short distance is used to elevate a smaller stream a greater distance.

As shown to the right, a bottom outlet is required from which the greater flow can be borne away. Should geologists find one subterranean river flowing above another having unused capacity, Patent Application 2005/0022997 might be useful.

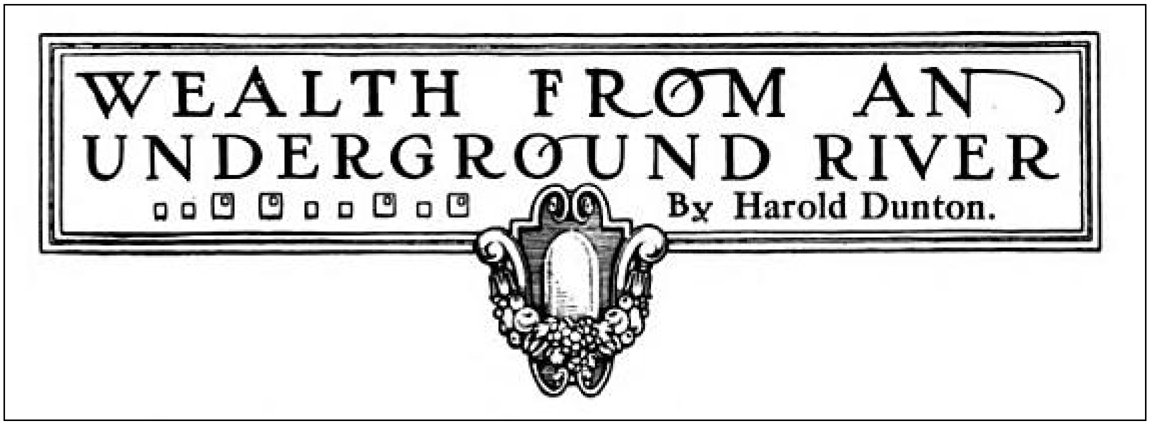
Conclusion

Apart from a few subterranean dams and a larger number of tunneled penstocks, little hydropower has been harvested underground, but we remain hopeful.

CHAPTER 63

THE LAW OF SUBTERRANEAN STREAMS

But why would lawyers care, a naive hydrogeologist might wonder? Technical World Magazine, March 1909, headlines the answer.



WEALTH FROM AN UNDERGROUND RIVER

By Harold Dunton.

Much development in the way of government and private projects for the irrigation of the Colorado desert, the Salt River Valley and the barren parts of eastern Oregon has been done, but there is an immense stretch of country, most of it level as a floor, lying to the east of the Siena Madre Mountains in Southern California which yet awaits the plow and the water canal. This is the Mojave Desert, on which it is probable that more men have died in search of gold than any other equal area in the world. Now one man has invaded the Mojave Desert, and, following out a theory of his own, has won from the barren land a home and a large rancho which bids fair, in a few yean, to make him one of the wealthy men of the West.

Underground water can be worth a great deal.

In the same vein -- no pun intended, William De Witt Hyde's Vocations (1911) was a useful guide for career chioce.

Forward to Parents

This book is made up of a series of articles selected from those available for the purpose and put together with the object of presenting a picture of the life and work of the men employed in some branch of the great vocation of the Mechanic Arts. It is hoped that a study of the book will help young men who may be looking in this direction for their calling, to form a worthy conception of what that calling really means.

"Wealth from an Underground River" by Harold Dunton

If he who makes two blades of grass grow where but one grew before is greater than the builder of cities, then there is a man in southern California, a pioneer of civilization along agricultural lines, who has done more than all the builders of all the cities since time began. He has made, not two blades of grass to grow in place of one, but whole alfalfa fields where there was nothing but a stretch of glaring sand; in place of sage brush and greasewood and juniper he has in successful growth orchards of apples and pears and plums; green fields of barley and corn turn to the yellow of early ripeness under his hand, and where the jack rabbit and the coyote, the crawling lizard and the hissing rattlesnake ruled the land he has set his home, carving the way for other men to come with him and share in the riches of an undiscovered farming land lying at the very doors of civilization.

> *The man is W.G. Dobie, a physician of ability, a globe trotter of years' experience, turned ranchman on the Mojave to prove or disprove an idea which had its origin in a casual trip across the great sand plat. This idea, which was that a great body of water, either lake or river, underlies the entire Mojave desert, he has completely proved, and he is now on the eve of reaping the rich harvest of his idea.*
>
> *Men and teams and drilling outfits were brought in; one, two, three hundred feet, straight down through sand, gravel, hardpan, and finally the bed of cement which is found beneath the entire floor of the desert, until at a depth of more than three hundred feet an abundant supply of sweet, fresh water was found. In addition to his theory of the great subterranean supply, Dr. Dobie had believed there would be force enough to this confined water to raise it to the surface in flowing wells. In this he was disappointed, but he found an endless supply of water, which could be pumped to the top of the ground.*
>
> *Soundings in the well proved it practically bottomless. The lead went down until it could no longer be controlled by the man at the surface, and was carried swiftly to one side, with a strength which the operator was scarcely able to withstand. With the greatest difficulty the cord and lead were withdrawn from the well, and the frayed condition of the cord showed that it had been rubbed on the rock roof of the subterranean channel with great force by the power of the water.*

"Go West, young man," popularized (but not coined) by Horace Greeley, was but half the story. "Go West, young man, and transform the West's underground rivers into riches."

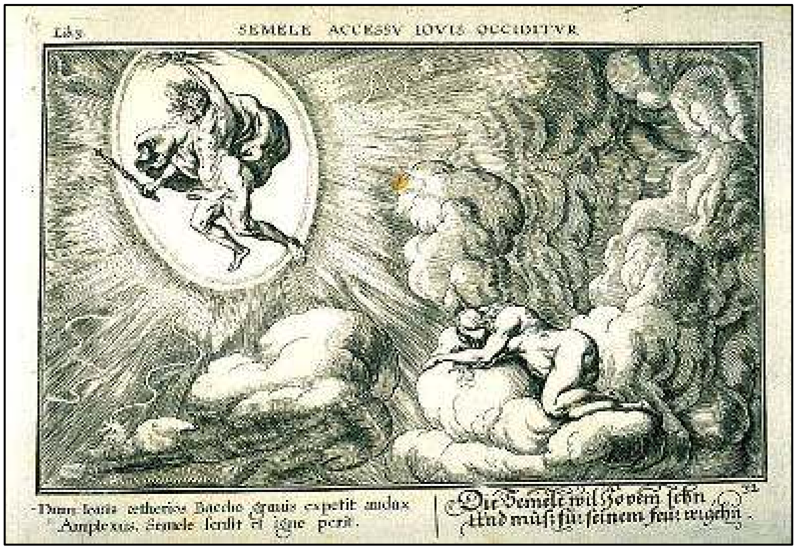
And where there's wealth, swarm attorneys.

To Swear by the Styx

The propriety of jurisprudence requires that truth be spoken, and for that end, we employ oaths.

The gods of Greek and Roman mythology would take life-binding oaths in the name of the Styx.

As depicted in the 16th century engraving to the right, Zeus swears by the Styx to give Semele, mother of Dionysus, that which she wishes and is thus obliged to yet comply when he realizes that her request will lead to her death.


Lib.3
SEMELE ACCESSV IOVIS OCCIDITVR
Dum Iouis ætherios Bacche grauis expetit audax
Amplexus, Semele sensit et igne perit.
Die Semele wil Jovem sehn
Und müs für seinem feür vergehn.

Helios similarly pledged his son Phaëton whatever he desired, likewise resulting in the boy's demise.

From the tale of Bacchus and Ariadne in Thomas Bulfinch's Age of Fable (1913),

> *Jove gives his promise, and confirms it with the irrevocable oath, attesting the river Styx, terrible to the gods themselves.*

The eighth-century BC Greek poet Hesiod wrote that in breaking such an oath, the gods were unable to move, breathe or speak for one year.

Acknowledging the politics of Niccolo Machiavelli (1469-1527), however, Sir Francis Bacon (1561-1626) remarked in his De Sapientia Veterum (1619) that while the Styx was respected by the gods, the word of a king, solemn and sacred as it might seem, has no authority above itself.

Machiavelli aside, swearing by the Styx has become a common reference to veracity. We'll quote a few examples.

From "The First Book of Statius's Thebais, translated in the year 1703," Poetical Works of Pope (1856) by Alexander Pope,

> *For by the black infernal Styx I swear, (That dreadful oath which binds the Thunderer)*

From Lord Rector Rosebery's address, "The High Standard," University of Edinburgh, 1882,

> *Work, my boy, work unweariedly. I swear that all the thousand miseries of this hard fight, and ill-health, the most terrific of them all, shall never chain us down. By the River Styx it shall not!*

From the Encyclopedia Britannica, a Dictionary of Arts, Sciences, and General Literature (1890),

> *Considering the prominence given by the ancients to an oath by the water of Styx, and comparing the effect supposed to follow from breaking that oath with the destructive power supposed to be possessed by the water, we are tempted to conjecture that drinking the water was originally a necessary part of the oath -- that in fact in the stories of the Styx we have traditions of an ancient poison ordeal such as is commonly employed amongst barbarous people as a means of eliciting the truth.*

A prudent, but not infallible, rule: Trust no lawyer who swears other by the River Styx.

Common Law

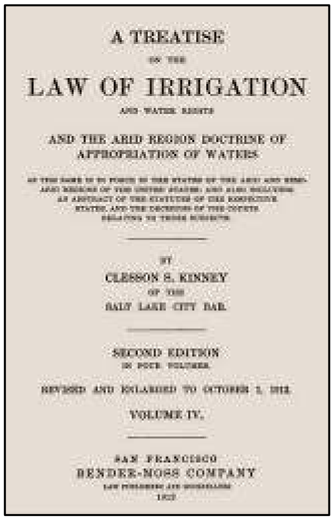
Underground or subterranean "rivers" are rarely mentioned in legal documents. Rather, there are a plethora of references to underground or subterranean "streams." While a court would deem the terms to be interchangable, the codified preference for the latter seems to suggest that legal drafters properly recognized that they were legislating relatively small waterways.

In A Treatise on the Law of Easements (1904), John Leybourn Goddard describes the English common law, the underpinning of the American legal framework.

> *Underground streams are of two kinds: viz., those, the course of which is defined and known, and those which merely percolate through the earth, without having any defined course, and in unknown channels. If the course of underground streams is defined and known, they differ in no respect from surface streams as to the natural rights of landowners and easements which landowners may acquire in them, but if water merely percolates through the soil in unknown channels, the same rules of law do not apply, and streams so formed differ altogether from defined streams on the surface of land. An endeavor has been made to establish the principle that if the course of an underground stream is defined it matters not that it is unknown, and that the same riparian rights belong to it as if the course were known. It has, however, been decided that the underground course must be both known and defined to support such rights. -- Chasemore v. Richards, 7 H.L.C. 349, 29 L.J., Exch. 305, (1859).*

Clesson S. Kinney and his A Treatise on the Law of Irrigation (1894). Kinney believed that an inexhaustible supply of water flowed in "subterranean or underground watercourses."

> *A large portion of the great plains and valleys of the mountainous regions of the west is underlaid by a stratum of water-bearing sand and gravel, and fed by the water from the mountain drainage. This water-bearing stratum is of great thickness, the water is moving freely through it, is practically inexhaustible, and, if it can be brought to the surface, will irrigate a large portion of the country overlying it.*



A TREATISE
ON THE
LAW OF IRRIGATION
AND WATER RIGHTS

AND THE ARID REGION DOCTRINE OF
APPROPRIATION OF WATERS

BY
CLESSON S. KINNEY
OF THE
SALT LAKE CITY BAR

SECOND EDITION
IN FOUR VOLUMES

REVISED AND ENLARGED TO OCTOBER 1, 1912

VOLUME IV.

SAN FRANCISCO
BENDER-MOSS COMPANY

Kinney was deluded, of course, regarding the inexhaustibility, but he didn't stop there.

> *These water-courses are divided into two distinct classes; those whose channels are known or defined, and those unknown and undefined. It is necessary to bear this distinction in mind in our discussion, as they are governed by entirely different principles of law. And in this connection it will be well to say that the word "defined" means a contracted and bounded channel, though the course of the stream may be undefined by human knowledge; and the word "known" refers to knowledge of the course of the stream by reasonable inference. Regarding the laws governing these two classes, it must be known that if underground currents of water flow in well defined and known channels, the course of which can be distinctly traced, they are governed by the same rules of law that govern streams flowing upon the surface of the earth.*
>
> *The owner of land under which a stream flows can, therefore, maintain an action for the diversion of it if such diversion takes place under the same circumstances as would enable him to recover if the stream had been wholly above ground.*

Given this understanding, it made sense to apply the legal rules of prior appropriation to water supposedly flowing underground in "known channels," as though these channels were also rivers or streams. All other underground water, inexhaustible in supply, was therefore available for pumping under the legal rules of reasonable use.

Joseph R. Long, in his influential A Treatise on the Law of Irrigation Covering All the States and Territories with an Appendix of Statutory Law (1902), endorsed Kinney's pronouncement.

> *Percolating waters have ordinarily no legal existence apart from the soil in which they occur, and therefore are not subject to appropriation for irrigation or other purposes. But where waters collect or are gathered in a stream flowing underground in a defined channel, no distinction exists between such subsurface streams and streams flowing upon the surface. They are such property or incidents to property as may be acquired by grant or by appropriation, and when rights in them are so acquired, the owner cannot be divested thereof by the wrongful acts of another.*
>
> *So far as the right of appropriation is concerned, there is no difference between the water flowing on the surface and the underflow, passing beneath the bed of the stream. One may, by appropriate works, develop and secure to useful purposes the subsurface flow of the stream, and, by so doing, become the legal appropriator of the water, provided he does not thereby interfere with the rights of other persons in the water of the stream.*

If the legal jargon seems tedious, here's a diagram.

Surface Water		Surface water law. Riparian rights inherent with overlying land ownership, and appropriative rights determined by seniority.
Groundwater	Subterranean Streams	
	Percolating groundwater	Groundwater law. Overlying and appropriative rights gained by pumping and putting to beneficial use.

Unfortunately, however, such common law distinction conflicts with science. The same water may sometimes be found on the surface and at other times below. What constitutes a "definite channel" is subjective. Whether seepage from the surface is at any particular moment below or not below a surface stream depends on the slope and direction of the medium through which the groundwater is moving at that time, the obstacles it encounters and the topography.

American groundwater law has never fully recovered from its misalignment with science. Most states still use the reasonable use doctrine to govern groundwater and employ a riparian and/or prior appropriation legal framework for surface water. Most states still administratively regulate the "subterranean stream" portion of groundwater as if were on the surface.

We will limit our court reporting to the 17 western states.

Western Contiguous States having Statutory or Judicial Reference to Subterranean Streams

Arizona	Ariz. Rev. Stat. Ann. § 45-101(1956)
California	Cal. Water Code §§ 1200 and 1201 (West 1971)
Colorado	Medano Ditch Co. v. Adams, 29 Colo. 317, 326, 68 Pac. 431 (1902)
Idaho	Public Util. Comm'n v. Natatorium Co., 36 Idaho 287, 305, 211 Pac. 533 (1922)
Kansas	Kans. Stat. Ann. § 82a-707 (1969)
Montana	Ryan v. Quinlan, 45 Mont. 521, 531, 533-534, 124 Pac. 512 (1912)
Nebraska	Olson v. City of Wahoo, 124 Neb. 802, 248 N.W. 304 (1933)
Nevada	Strait v. Brown, 16 Nev. 317, 321 (1881)
New Mexico	Keeney v. Carillo, 2 N.Mex. 480, 495-496 (1883)
N. Dakota	Baeth v. Hoisveen, 157 N.W. (2d) 728, 730 (N. Dak. 1968)
Oklahoma	Okla. Stat. Ann. tit. 60, § 60 (1971)
Oregon	Taylor v. Welch, 6 Oreg. 198, 200-201 (1876)
S. Dakota	Metcalf v. Nelson, § S. Dak. 87, 89, 65 N.W. 911 (1895)
Texas	Houston & T.C.R.R. v. East, 98 Tex. 146, 81 S.W. 279 (1904)
Utah	Chandler v. Utah Cooper Co., 43 Utah 479, 135 Pac. 106 (1913)
Washington	Meyer v. Tacoma Light & Water Co., 8 Wash. 144, 146-147, 35 Pac. 601 (1894)

Wyoming's always been a special case. As reported in toto by the Huron Expositor, July 30, 1886,

> *An underground river has just been discovered in Wyoming Territory. It is just in the nick of time. Had its discovery been postponed until next fall, it would have been too late for an appropriation from Congress this year.*

We're left to wonder what legislative action hung on the timely discovery. As the Huron Expositor published in Ontario, Canada, we wonder why the underground river story merited international coverage, scant as it was.

Of the western states of today, only Wyoming makes no explicit mention of "underground streams" or "underground rivers" in its statutes and rulings. All water below the surface is designated simply as "groundwater."

While each of the remaining states acknowledges a legal distinction between subterranean streams and percolating groundwater, Idaho, Kansas, Nevada, North Dakota and Oregon regulate both as indivisible groundwater.

That leaves Arizona, California, Colorado, Montana, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, Utah and Washington as states where the distinction between subterranean streamflow and percolating groundwater may impact the rights.

This is not to say, however, that one would have a good chance in court of appropriating water beneath one's real estate based on a riparian right.

We will look at the water law of three states that fall into this latter category, states that continue to wrestle with subterranean streams having surface stream status.

Arizona

Arizona, where "whiskey is for drinking and water is for fighting," distinguishes "subflow" from percolating groundwater.

The first official water rules came as provisions within the Howell Code of 1864 by the Legislative Territorial Assembly. Groundwater could be distinguished as either subsurface water which flows in definite underground channels or water seeping down into non-tributary permeable soils. Subsurface water flowing in underground channels was subject to the law of prior appropriation. Not thought capable of lateral movement, percolating waters were considered similar to mineral deposits.

To establish the existence of a subterranean stream, the state supreme court specified,

> *While surface indications such as trees, shrubs, bushes, and grasses growing along the course and the topographical features of the surface are the simplest and surest methods of proof, we think they are by no means exclusive. Other methods may be used, such as a series of wells or borings, tunnels, the color and character of the water, the sound of water passing underneath the earth, the interruption of the flowing of other wells on the line of the alleged subterranean stream, geologic formation, and perhaps others.* -- Maricopa County Municipal Water Cons. Dist. No. 1 v. Southwest Cotton Co., 39 Ariz. 65,4 Pac. (2d) 369,377 (1931)

A hydrologist familiar with arid regions would take exception to the "surest methods of proof." Few (if any) dry washes or arroyos sustaining a strip of phreatophytic vegetation overlie anything resembling flowing water. "The sound of water passing underneath the earth" would prove the point, but it's not an Arizona sound.

Fortunately, we note, the art of dowsing is not a court-sanctioned indicator.

To the state's credit, Arizona recognizes the dichotomy between modern hydrology and long-held legal frameworks.

> *The notion of "subflow" is significant in Arizona law, for it serves to mark a zone where water pumped from a well . . . should be governed by the same law that governs the stream. Yet the notion of subflow is an artifice... that rests on a hydrological misconception.* -- General Adjudication of All Rights to Use Water in the Gila River System and Source (1999) 195 Ariz. 411, 415

Rather than reject the deep-rooted common-law distinction between subterranean stream and percolating groundwater, states such as Arizona have simply raised the burden of proof. The ruling continues,

> *But all of these, when examined, must be such as to afford clear and convincing proof to the satisfaction of a reasonable man, not only that there are subterranean waters, but that such waters have a definite bed, banks and current within the ordinary meaning of the terms as above set forth, and the evidence must establish with reasonable certainty the location of such bed and banks. It is not sufficient that geologic theory or even visible physical facts prove that a stream may exist in a certain place, or probably or certainly does exist somewhere. There must be certainty of location as well as of existence of the stream before it is subject to appropriation.*

As the likelihood of such demonstration, at least in arid zones, is negligible, there is accordingly scant history of successful arguments, other than where an underground stream was a discernable and defined result of an artificial water work.

California

Recalling a line from the movie Chinatown (1974), "Either you bring the water to L.A. or you bring L.A. to the water," we'll go to the Golden State.

"Property Rights in Underground Water Flowing in Defined but Unknown Channels," The Columbia Law Review 3:2, 1903, summarizes the challenge faced by California.

> *It is well settled that when water flows underneath the surface in a defined and known channel, a riparian proprietor has the same rights to its reasonable use which he would have enjoyed if the stream had been on the surface, that is, in such a case the principles applicable to surface streams, govern, and not to the principles which relate to percolating waters. However, as there have been few decisions in which the right to use water flowing in an underground channel has been directly in issue, some doubt bas existed as to just what qualities are necessary to make an "underground channel" defined and known."*

In Hale v. McLea 53 Cal. 578 (1879), where the course of an underground stream was marked by vegetation which would grow nowhere except above such waters, it was held that the channel was indeed well defined and that a lower riparian proprietor had a right to the flow.

In Bradford v. Ferrand, 71 L.J. Ch. Div. (1902), the plaintiff maintained that a spring issuing from the defendants' land was fed by a subterranean stream flowing in a defined channel. The plaintiff desired to prove his contention by excavating upon the defendants' land (and in logical extension, digging on any number of proprietors and thus extending the stream for miles.) In this case, the court decided that the course of the channel must be ascertainable by the reasonable inference of men of ordinary powers without the use of exploratory excavation.

Hudson v. Dailey, 156 Cal. 617, 627 (1909) adopted a “common source” or “correlative rights” doctrine, providing that where surface and groundwater rights are interconnected, water rights are likewise integrated.

> *In the case of percolating waters feeding the stream and necessary to its continued flow . . . There is no rational ground for any distinction between such percolating waters and the waters in the gravels immediately beneath and directly supporting the surface flow, and no reason for applying a different rule to the two classes, with respect to such rights, if*, indeed, the two classes can be distinguished at all.

The classification was retained in the state's Water Code of 1943

> *Whenever the terms stream, lake or other body of water, or water occurs in relation to applications to appropriate or permits or licenses pursuant to such applications, such terms refer only to surface water, and to subterranean streams flowing through known and definite channels.*

The physical distinction between subterranean streams and percolating groundwater has traditionally been based on the Los Angeles v. Pomeroy, 124 Cal. 597 (1899) "bed and banks" test which ruled that subsurface water should be classified as percolating groundwater unless it can be shown that it flows through known and definite channels, and thus is a subterranean stream.

Judge George H. Hutton, wasn't impressed with the distinction, as evidenced by his contribution, "Underground Waters of California" National Irrigation Congress (1910), but an article doesn't convey the weight of law.

> *An underground river in California is a geological myth. The idea must have been born in some facetious brain and treated literally by a large number of gentle and confiding persons who believe everything they hear, until some serious-minded men took it up and for a time exploited the idea and then exploded it.*

In the Matter of Applications 30038, Waste Management, Inc., Applicant; Yuima Municipal Water District, Protestant; Pauma Valley Water Co., Interested Party -- better known as the Pauma and Pala case (1999) -- however, the SWRCB attempted to reclassify ordinary groundwater as subsurface streamflow despite the fact that no impermeable bank beneath the stream could be demonstrated, arguing that that bedrock mountains flanking the basin constitute "banks." Under such definition, all groundwater basins in California could potentially be classified as subterranean streams.

Prof. Joseph Sax reviewed the legal issues in Review of the Laws Establishing the SWRCB's Permitting Authority over Appropriations of Ground Water Classified as Subterranean Streams and the SWRCB's Implementation of those Laws (2002). Among his findings,

> *The categories that statutes and judicial opinions use, such as "underflow," "subflow," "subterranean streams," and "percolating groundwater," bear little if any relationship to these geological realities...*

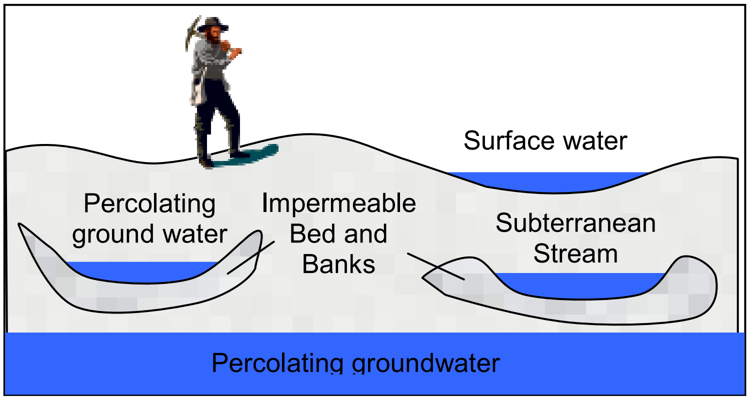
Referring to precedent, Sax noted,

> *The principal point of contention in the case was whether the alluvium from which the well was pumping had "relatively impermeable" bed and banks, which the Board defined as follows.*
>
> > *Is the [material comprising the bed and banks sufficiently] impermeable at the point of diversion to prevent the transmission of all but relatively minor quantities of water through the*

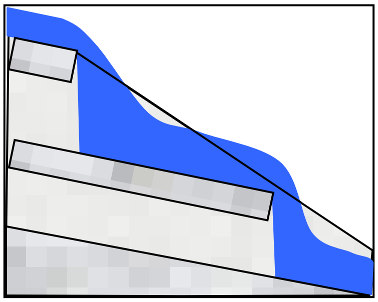
> > *channel boundary... The test is not that the bed and banks be absolutely impermeable, but rather, relatively impermeable compared to the alluvium filling the channel.*
>
> *If the Board were to take the view that a channel must fit the definition of being like "a trench, furrow, or groove" or "a tubular passage" -- that is, something essentially long and narrow -- it would doubtless be drawn toward the more restricted view of its jurisdiction that some urge, sticking to the immediate confines of the channels of surface streams. On the other hand, if a channel can be quite broad and un-furrow-like, so long as it is enclosed by relatively impermeable beds and banks, subterranean stream jurisdiction could be quite extensive.*
>
> *Assuming a highly impervious enclosure, subsurface water that fits everyone's legal definition of a "subterranean stream flowing through known and definite channels"... should be limited to what is called the underflow of surface streams.*

Water not underlying a surface channel should not be classified as a subsurface stream. Water enclosed by impermeable boundaries beneath a surface stream, however, might constitute a subsurface stream and thus could be regulated as is that flowing above.

In the drawing to the right, it makes no legal difference whether the two perched water bodies are flowing or quiescent.



A correspondence between a surface channel and a corresponding subsurface flow -- "affinity" in legal jargon -- can make hydrologic sense, as illustrated to the right. Indeed, disappearing and reappearing streams are not uncommon in arid regions. It would make little sense to change the legal model every time the stream takes a subterranean dive.



As summarized by David Aladjem in "Groundwater Management in California, The Sax Report and Beyond," California Water Law & Policy Reporter, July 2002,

> *The Sax Report crystallizes two concepts that have gained some popularity and credence during the past few years. First, the Sax Report advocates that Water Code § 1200, which grants the SWRCB authority over "Subterranean streams flowing through known and definite channels," be read to grant the SWRCB authority over groundwater when the extraction of that groundwater would have an "appreciable and direct impact" on a surface stream. Second, the Sax Report indicates that the SWRCB possesses and should exercise authority over groundwater, either under the public trust doctrine or under the waste and unreasonable use doctrine, when the extraction of that groundwater might have an adverse impact on instream values.*

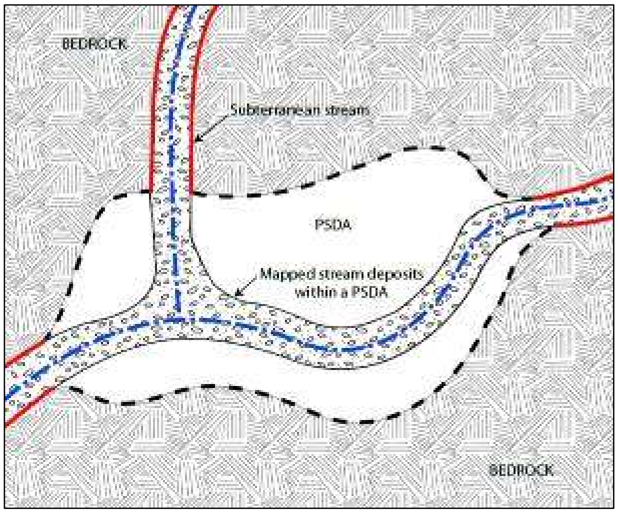
Aladjem, on the side opposing the report, provides several legal arguments against Sax's findings, the last being,

> *Third, and most important, the Sax Report -- like much current dialogue about groundwater – proceeds on the assumption that the interconnected nature of groundwater and surface water requires an integrated legal regime. Examining the differences between groundwater and surface water, however, suggests that there are sound policy reasons that California has decided to treat those two resources separately.*

Only a big-city lawyer could argue that the law working one way and nature, another, is sound public policy, but such arguments prevailed and Sax's contribution was rejected by state.

As things remain in the Golden State, for there to be a subterranean stream, the following conditions must be present:

1. A subsurface channel must be present;
2. The channel must have relatively impermeable bed and banks;
3. The course of the channel must be known or capable of being determined by reasonable inference; and
4. Groundwater must be flowing in the channel.

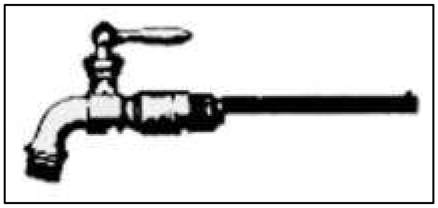


Relationship between subterranean streams, potential stream depletion areas (PDSAs) and mapped stream channel deposits

The contentiousness is not put rest, but argument to justify the presence of subterranean streams (and thus a rash of private-property drilling) appears to be evidentially thwarted.

Texas

When in the Great State of Texas, a man's water right is challenged, “Them thar’s fightin’ words, mister.”



To illustrate the economic importance of our topic, here is an item from the Port Jefferson Echo, June 17, 1926, "Wide Underground River Discovered in Texas."

> *San Marcos, Texas. Discovery of what is believed to be an underground river of a width of perhaps one-half mile and of undeterminable depth, has transformed the arid region 15 to 25*

> *miles northwest of here into a variable paradise of verdure and growing crops within a period of three months.*
>
> *Is was during the height of the recent severe drought that Ben W. Pyland, a farmer, decided to dig a well on his place in search of water. He was ridiculed for attempting to get water in that locality by digging a well.*
>
> *Pyland commenced digging and at a depth of 20 feet he struck a cap of limestone. Using his pick vigorously he punctured this covering and there immediately gushed forth a small torrent of water. He enlarged the hole by exploding a charge of dynamite, and the water poured into the well, almost filling it to the top.*
>
> *Other farmers in the section began digging wells and several of them obtained water in apparently inexhaustible quantities.*

It's the same aquifer at which we looked in Chapter 48, Diversity in Darkness, but that chapter was about critters. Here we're talking about dollars, lots of them.

The Edwards aquifer has long been an item of contention between Texan landowners and regulators. Farmers and ranchers who draw from the Edwards maintain that what's under their property is theirs to pump, a principal founded in English Common Law.

The Texas Water Commission (TWC, whose Austin headquarters sits above the Edwards) considers the aquifer to be an integral component of the region's water. Just as TWC regulates surface water diversion by a system of permits, TWC claims authority over what's below.

The TWC uses "Edwards Underground River" 86 times in 31 TAC sec. 298, the enabling legislation, e.g.,

> *Except as provided by subsection (b) of this section, the owner of each well which diverts water from the Edwards Underground River, other than a well that is exempt under sec. 298.12 of this title (relating to Permit Exemption for Domestic and Livestock Use), shall, prior to diversion from the well, install and maintain a measuring device designed to indicate the flow rate and the cumulative amount of water diverted by that well.*

As to why it's denoted an "underground river," the Texas Water Code recognizes four classes of water:

1. Natural Surface Water: "The ordinary flow, underflow, and tides of every flowing river, natural stream, and lake, and of every bay or arm of the Gulf of Mexico, and the storm water, floodwater, and rainwater of every river, natural stream, canyon, ravine, depression, and watershed in the state." A central feature of this doctrine is the "first-in-time, first-in-right" rule that during times of scarcity, the water goes to the holder of the most-senior rights. All natural surface waters in are owned by the state and are held in trust for the people.
2. Diffused Surface Water: "Water that does not flow in any defined watercourse, but instead flows across the surface of land in a variant and un-patterned way." This includes rain or snow runoff and water left in upland areas after a flood recedes. Diffused surface waters are the property of the landowner until they enter a natural water course, at which time they become subject to state allocation and control.
3. Percolating groundwater: "Water beneath the land surface which fills the pore spaces of rock and soil material and which supplies wells and springs." In contrast to surface water regulations, Texas allows landowners an absolute "right of capture" to groundwater under their property. A property owner may pump as much water as needed, even if other property owners are affected, similar to the rule for oil and gas.
4. Underground Rivers: "Defined subterranean streams or the underflow of rivers" (Texas Water Code Ann. 52.001(6) Vernon Supp. 1992). The aquifer must show "all of the characteristics of surface water courses, such as beds, banks forming a channel, and a current of water." Underground rivers may be property of the state and governed by surface water rules.

TWC could regulate the Edwards aquifer within established legal theory if the classification were that of an "underground river." Following is a chronology of TWC's attempt to legitimize the designation.

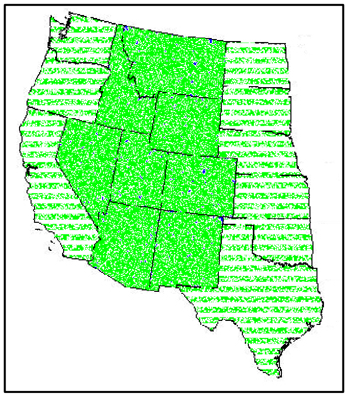
June 15, 1989	Guadalupe-Blanco River Authority (a smaller agency with interests akin to those of TWC) files suit to have the Edwards declared an underground river.
April 15, 1992	TWC moves to designate the Edwards as an underground river on an emergency basis, allowing TWC to regulate withdrawals in the system used for surface streams. Of notable deficiency in the filing is why the Edwards now qualifies as an "underground river" per the four-class criteria. There is no mention of "bed," but the Edwards moves within its "banks."
May 1992	House subcommittee public hearing to discuss the emergency rule. Opposition from the Texas Farm Bureau: "We oppose the classification of any aquifer as an underground river that would be regulated by the state."
July 1992	TWC argues that the action protects rural landowners from unbridled municipal and industrial pumping. Quoting the attorney, *There is not another aquifer in the state of Texas that exhibits these peculiar characteristics... I have no problem with the legislature passing a bill that says no other aquifers in the state are underground rivers... We took this action not because we wanted to get in the middle of a tug-of-war but because we felt it was necessary to bring about effective management for that resource.* The "effective management" basis would have startled the judge.
Sept. 9, 1992	TWC makes the rule permanent.
Sept. 11, 1992	District Court voids the "underground river" designation on grounds that TWC lacks statutory jurisdiction to alter conventional references to underground water.
Oct. 2, 1992	Judge issues Final Summary Judgment Order.
May 1993	Texas Senate Bill 1477 declares the Edwards to be not an underground river, but a distinctive natural resource. The ranchers prevailed legally -- the Edward's is not a river -- but what was once held to be the private property became subject to river-akin permits and regulation. The attorneys were well paid and gunfire was avoided.

But here's another Texas case, one of opposite outcome. From the abstract of "Dye Tracing, Its Application to Ground Water Law for Defining 'Subterranean Streams' in Karst Terrains," Proceedings of the Environmental Problems in Karst Terrains and their Solutions (1986), National Water Well Association, by A.E. Ogden,

> *The City of Camp Wood, Texas, obtains its water from Old Faithful Spring which emerges from the Glen Rose Limestone. Since the water was considered groundwater, no water-use permit was required. The source of Old Faithful Spring was believed to be sinking water of Camp Wood Creek. When developers planned to place impoundments on Camp Wood Creek, the City became concerned. The sinking stream was then traced to the spring using fluorescein and rhodamine dyes and optical brighteners. The tracer flowed four miles in just twenty-four hours. The hearing examiner and the State's lawyers decided that based on the groundwater traces and the velocity of movement that this water was in a "well defined subterranean stream" and should be considered as surface water. The City of Camp Wood then was required to obtain a water-use permit. Their prior-use superseded in time and importance the desired use of the developers, thus saving the spring.*

Four miles in 24 hours is about 4.5 meters/minute. As the quickest flows in typical aquifers tend to be measured in meters/hour (gravel, per the table of Chapter 38, Hydrogeology), the Glen

Rose water is whistling and the hearing officer had physical basis to declare the subsurface water to be a stream, not mere percolation.



Water Rights

We'll not kid ourselves about these Arizona, California and Texas cases. They're not about hydrology. They are about property rights.

As noted in this chapter's first table, subterranean streams fall under surface water law, which in the western states is a system of prior appropriation -- "first in time, first in right." The states shown in green exclusively employ this framework. The striped states blend in some aspects of riparian law, but not enough to make effectual difference in regards subterranean streamflow rights.

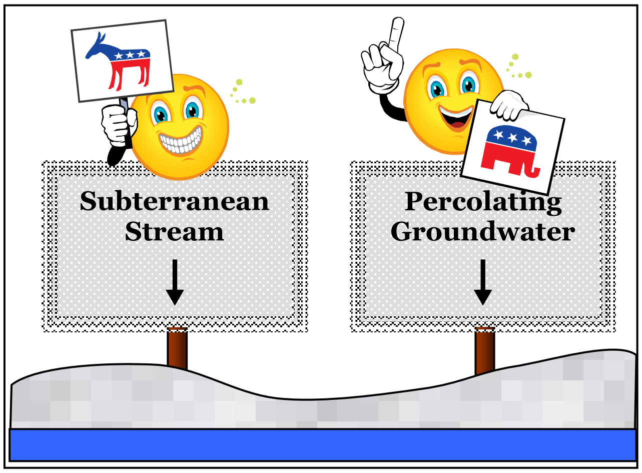
Our examples illustrate a litigation scenario common in the western states. In pursuit of comprehensive water resources policy, the regulator argues for the physical validity of subterranean streams to which the doctrine of prior appropriation would be applied. As this water would not be new water to the hydrologic system -- it's just another tributary to an already-fully appropriated resource -- the doctrine of prior appropriation effectively precludes additional claims. "Sorry, mister, but that there water's already taken. Now get on your horse and move on!"

To sidestep such austerity, the landowner argues that what's in question is percolating groundwater, thus moving the court case to the historically more-lenient domain of groundwater law. Water can be withdrawn from a well regardless of whether senior surface water rights are receiving their full entitlement. "Now listen, buster, this here is my land. Now skedaddle!"

As the state predictably fails to scientifically prove its claim of definite subterranean streamflow, the landowner most often prevails. The demise of Ogallala aquifer (Chapter 38 and the eastern states of the map above) speaks to the wisdom of such management, but we'll not confuse the weighing scale of justice with water balances.

If we favor comprehensive resource management, we tend to imagine subterranean channels beneath us. If, on the other hand, we wish to avoid government interference on what we do on our own land, what we're drilling into is just percolating groundwater.

Given the philosophical difference between the two major American political parties -- though some Democrats act Republican and some Republicans act Democrat -- we can take a guess as to how legislation regarding subsurface waters thus tends to play out.



Federal Law

If it should get past committee, H.R. 2889, the Oregon Caves National Monument Boundary Adjustment Act of 2009, would make the cavern's River Styx -- yes, like many caves, it has one of that name -- into a "recreational" river, the first underground river in the nation subject to the Wild and Scenic Rivers Act.

Given its size -- see the photo to the right -- it is questionable how much recreation the river can sustain, but the legislation protects if from degradation.

But perhaps the oddest legal twist of all was using underground rivers as rationale for reading the Bible in public schools. In 1869, the Cincinnati School Board banned hymn-singing and Bible reading in the public schools and conservative Christians brought suit to block the ban.

Here's the argument of Rufus King against the ban, quoting from The Bible in the Public Schools, Arguments in the Case of John D. Minor et al. versus the Board of Education of the City of Cincinnati et al., Superior Court of Cincinnati ; with the Opinions and Decision of the Court (1870) by John D. Minor.

> *There has been a great deal said here about zoology. I recollect seeing a poor little blind fish, taken out of the subterranean river in the Mammoth Cave; proving, as I suppose, the fact that the river must be subterranean, because it had no eyes whatever. There being no light the organ lost its purpose; it had shrunk away, and there was nothing there but a slight speck and a slight bony process where the eye might have been. And that is what it is proposed to make out of the children of this city. Educated in a medium destitute of the blessed rays of God's light, the only inspiring source of virtue, brought up purposely in blindness and darkness, with no vision to their souls, they are to be kept here groping about without knowledge of the Creator and Giver of all these things that they are reading in these books of exact science; and I suppose the best of them would be in the sad, helpless condition ascribed to Humboldt by one of the orators at the late anniversary of his birthday, who ended his oration, put the climax to it, by declaring that Humboldt died, having discovered that the universe was governed by fixed laws. Wondrous Eureka! Promethean, yea, godlike science! The great Humboldt, whose mind could glance from heaven to earth, and who penetrated all things in space, expiring with the discovery that the world was governed by fixed laws, and yet knew not, as the poorest little child in the public schools in the city, simply holding the Bible in his hands, could have told him, who was the author of those laws: "the hand that made us is divine."*

It's again the Hydrotheology/Theohydrology juxtaposition of Chapter 13.

The Board lost in a two-to-one vote and was enjoined from enforcing its ban on Bible reading. The Scopes trial of 1925 didn't cite underground rivers.

Europe

Groundwater law varies between European nations regarding private vs. public rights, the law of Belgium, for example, favoring the overlying landowner, while that of the former Soviet Union retaining a public-ownership bias. With a few exceptions, however, the water beneath the surface of the ground in a particular nation is not further subdivided regarding legal theory.

Great Britain, as we have seen, is an exception, the Queen's view of percolating groundwater different from that regarding defined subterranean streams.

Spain considers waters under a streambed or in the subsoil within 100 meters of a public stream to be public waters. Other groundwater is private property. While stream-associated groundwater is not defined, per se, as a "subterranean stream," the property rights consequence is much the same as that of the United Kingdom, California and Arizona.

Italy subjects thermal and mineral waters to unique regulation, again without reference to "subsurface stream," but seemingly in extension of an historical perspective that thermal and mineral waters travel via confined courses.

In conclusion, let us note that water law based on arbitrary hydrologic partition tends toward problematic enforcement. "Underground rivers" indeed hold an honored place in western culture, but it's unfortunate that they hold any place at all in jurisprudence.

CHAPTER 64
CAVE DIVING

While some underground rivers are navigable by boat, there are the darker waters beneath to also explore.

While such photography can make cave diving appear idyllic, not all underwater passages are as well illuminated and spacious, an environment many of us would choose to avoid. But as our underground river voyage beckons us into darker realms, we'll investigate.

Chapter 68, More Periils, expands the list of unfortunate outcome possibilities due to underground rivers. As there's so much more to cave diving than danger alone, however, we're granting the subject a full chapter.

We'll not classify cave diving as a recreational sport -- which it is for many -- because it's also a means of exploration and scientific research -- geological, biological, paleontological, and even archeological.

The Problem of Hypothermia

Today's divers are outfitted with customized wetsuits, but earlier explorers had to invent their own protection against the cold.

From Peter Harvey's internet posting, "Early Days in Dan yr Ogof,"

> *Before the days of wetsuits [or furry suits], Dan yr Ogof was a cold cave. After wading through the lakes, which usually meant getting soaked up to the armpits or higher, one tended to get As this series consisted in the main of large chambers, the caving was not energetic enough to generate much heat. Also there was a considerable draught in the cave which contributed to the general chill. Some of the old hands such as Platten used to cover their bodies with about half an inch thick of lanolin grease before putting on their caving gear.*

FIRST AID KIT IN A JAR
Vaseline
WHITE PETROLEUM JELLY

From Charles Freeman in the British Caver (1941),

> *Also a wonderful difference can be made by greasing the body all over, when changing into caving rags, with commercial vaseline. A handful should be taken up and rubbed well into the skin, not just smeared on… Its use certainly transforms one into a hero in the eyes of those who have scorned to anoint themselves.*

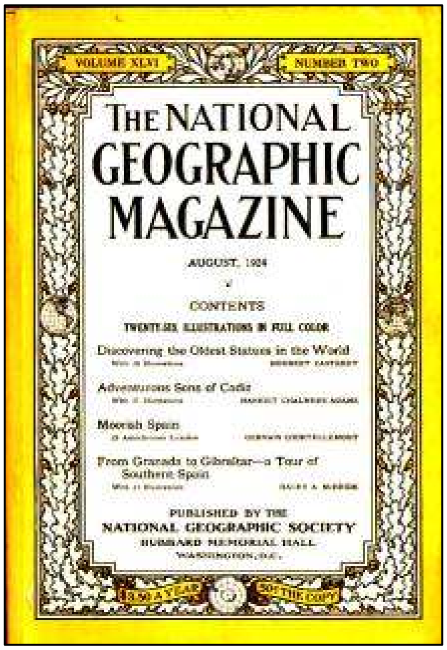
Norbert Casteret discusses an early wetsuit in My Caves (1947).

> *The thing weighs just over a pound and a half; it is made of balloon cloth, as thin as a handkerchief but very strong, the lightest of diving dresses, which in no way interferes with the movement of the body. At the same time, a thin skin like this is not meant to be scraped against rough walls or sharp rocks, so it is advisable to put the boots on over it and then the usual cave overall. Thus clad, the diver is completely covered up and protected, and it is great fun to plunge fully dressed into an underground stream, even in winter, to the amazement of friends or sightseers, who fail to realize that the overall and boots are the only things which the water penetrates. If only I had known of this wonderful diving dress for caves fifteen years earlier, I should have been spared the horrible times I have spent with chattering teeth in icy water, and I should have doubtless also avoided the rheumatism that is coming to me in the future, and which, when it has me in its grip, will cause me no surprise and will leave me in no sort of doubt as to how I invited its attack.*

Free Diving

There's rudimentary equipment involved -- we've had the mask, snorkel and fins since the 1920s -- but the fundamental limit of free diving is the duration one can hold his or her breath, for most of us probably not much more than a minute. A free dive isn't likely to propel us more than a few meters deep and some tens of meters in distance. In the case of a flooded cavern, of course, the assurance of an air pocket ahead -- the inverted siphon configuration of Chapter 44 -- is denied to the first explorer.

We'll start by looking at an early free dive beneath the foothills of the Pyrenees.



VOLUME XLVI NUMBER TWO

THE NATIONAL GEOGRAPHIC MAGAZINE

AUGUST, 1924

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TWENTY-SIX ILLUSTRATIONS IN FULL COLOR

Discovering the Oldest Statues in the World

Adventurous Sons of Cadiz

Moorish Spain

From Granada to Gibraltar—a Tour of Southern Spain

PUBLISHED BY THE
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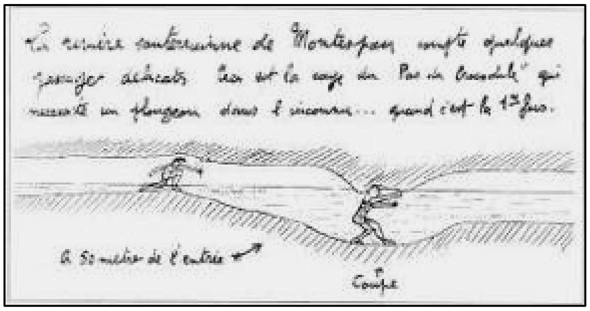
To penetrate Montespan Cavern in 1922, explorer Norbert Casteret had to swim unassisted through two inverted siphons. "Discovering the Oldest Statues in the World, A Daring Explorer Swims Through a Subterranean River of the Pyrenees and Finds Rock Carvings Made 20,000 Years Ago," National Geographic, August 1924, chronicles the feat.

> *Putting my candle on a projection of the wall, I breathed in enough air to last me for two minutes under the water (a habit to which I am accustomed) and plunged into the stream with one hand ahead of me, the other in contact with the submerged roof*
>
> *While thus hurrying forward, suddenly my head emerged from the water and I could breathe. Where was I? I had not the slightest idea. The darkness was absolute. Without doubt I had passed through a siphon tunnel. Immediately I turned around and dived toward the spot from which I had come, for nothing is more dangerous than to lose one's sense of direction in such a case.*


La rivière souterraine de Montespan compte quelques "passages délicats" ceci est la coupe du "Pas du Crocodile" qui nécessite un plongeon dans l'inconnu... quand c'est la 1re fois.
à 50 mètres de l'entrée
Coupe

Casteret's field sketch -- not included in the National Geographic report -- suggests that the underwater passage may have been something less, however. The submerged rock wasn't large and, had the route not reopened within the first minute, the explorer would have had breath enough to back out. (The passage is less rigorous today, as the water level has been lowered by excavation.)

How many other cave explorers, we wonder, have blindly dived into longer flooded passages without a subsequent air pocket, thus becoming a news story, not a National Geographic contributor? But back to 1922,

> *Having undressed and hidden my clothes in the bush, I lowered myself into the subterranean stream, holding in-one hand a lighted candle and in the other my rubber bathing cap containing matches and candle*
>
> *This simple case, kept well closed, would permit me to pass under the water and have after each dive into the stream the means of relighting my candles. (May I add, that to supplant this mode of lighting by' an electric pocket lamp is imprudent in a cave, for some dry batteries have a very limited duration and sometimes suddenly go out.)*
>
> *Arrived at the siphon, I took the precaution to orient myself, as on the preceding day, in order to find again the pocket of air, and, diving through the siphon a second time, I found myself on the other side, immersed lip to my chin.*
>
> *I shook my dripping cap before relighting a candle with all tile impatience that was consistent with caution.*
>
> *At last the flickering flame enabled me to observe that, as far as the eye could see, the roof was parallel to the surface of the water, which was separated from it by a thin layer of air.*

> *This time my anticipations were realized, for I was exploring a subterranean stream hitherto unknown.*

A more-recent and less fortunate story from Utah:

> *Searchers recovered the bodies of two women and two men who had tried to swim underwater through a narrow submerged passageway in a cave in an effort to reach another chamber, officials said Thursday.*
>
> *He said the entrance to the passageway is a hole visible at the bottom of a pool of clear water, about five feet deep, that sits some 30 yards inside the cave.*
>
> *"We believe they'd already been into the cavern and were on their way out when something went wrong," said Lt. Dave Bennett of the Utah County sheriff's office search and rescue team.*
>
> *All the bodies were found in the underwater passageway, facing toward the entrance as if they were swimming out, he said.*
>
> *The chamber is reachable by a water-filled passageway about 15 feet long with a guide rope tied to a rock at the opening and to a piece of wood inside the chamber.*
>
> *"There are 2 or 3 feet of breathable air above the water in that next chamber, which could hold about eight people," he said.* -- Associated Press, Aug 18, 2005

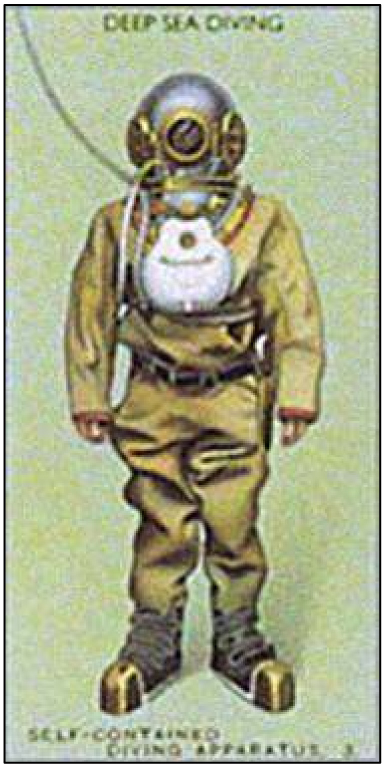
The physiological limit of oxygen deprivation didn't change between 1922 and 2005. Casteret, as well conditioned as he thought himself to be, was fortunate that the siphon was short; the Utah spelunkers weren't as lucky.

The Standard Helmet Diving Suit

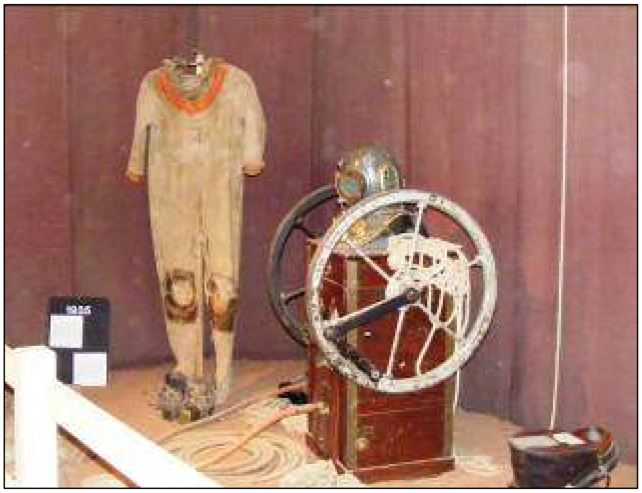
The Standard Helmet Diving Suit, characterized by its large helmet, heavy boots and durable air lines fed by a surface pump, was invented in 1830. Not substantially changed over the years, it was to remain the basic diving apparatus for more than a century

The first recorded helmeted cave dive, 23 meters into France's Fountaine de Vaucluse, was in 1878 (Chapter 65, Subterranean Shipwrecks), followed by Switzerland's Orbe Spring in 1893 and Austria's Lurloch Cave in 1894.

In 1934, Switzerland's La Grotte du Creugenat was explored with the same standard apparatus.



Wookey Hole (Chapter 51, The Tourist Trade Worldwide) was explored to its seventh chamber in 1935. Divers had to physically walk on the floor of the sumps while the team pumped gas to them using a seesaw pump. To the right is equipment from that era, the pump in this case being rotary.

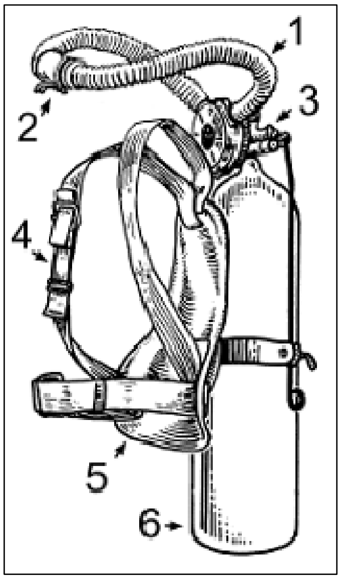


In 1936, divers passed the first sump of Swildon's Hole (an upstream feeder to Wookey) using a suit fed by a football inflator/bicycle pump. An oxygen cylinder affixed to the heavy suit allowed passage of the second sump.

Diving in the spacious third chamber was aired live on BBC radio.

Scuba

Jacques Cousteau and others developed the self-contained "aqua lung" In 1942, the breakthrough being the regulator delivering properly pressurized air only when the diver breathed in. Today we know the technology as "scuba" (acronym for self-contained underwater breathing apparatus) gear.



MALTA
16c
JACQUES COUSTEAU
1910-1997

1. Air Hose
2. Mouthpiece
3. Regulator
4. Harness
5. Back plate
6. Tank

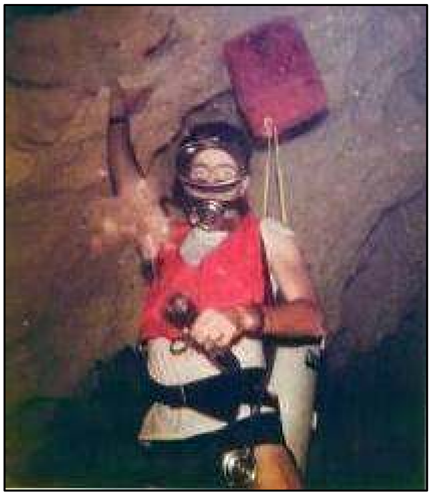
Within four years, the Cave Diving Group was established in the UK for cavers who wished to dive, not divers who wished to cave.

The first scuba cave dive in America was in 1951, a descent into Florida's Silver Springs sinkhole.

The first cave dives in Wakulla Springs, Florida (Chapter 52, The American Tourist Trade) occurred in 1955. Divers with virtually no protection from the cold penetrated approximately 150 meters reaching depths of 78 meters, discovering Pleistocene era fossils including camel, deer, sloth and mastodon.

A 1956 photograph is to the right.

In the 1960s, divers with cobbled improvements were penetrating many of Florida's underground rivers. Gas cans (as illustrated), plastic milk bottles or Clorox jugs were used for floatation. Three-watt lights provided illumination.



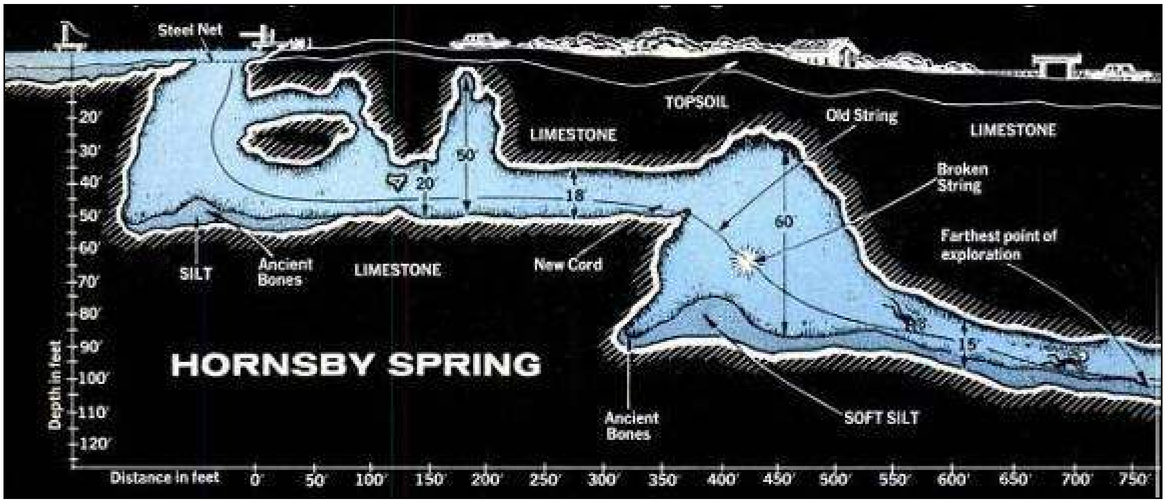
"Exploring Florida's Treacherous Underground Rivers," Popular Mechanics, April 1968, illustrates how the popular press drew upon cave diving's danger to spice up publications.

Are Cars Really Getting Better? Page 80
POPULAR MECHANICS
Build This 3-Stage
VACATION HOUSE
See Page 138 for Others You Could Be in by Summer
Exploring Florida's Treacherous Underground Rivers
Merciful as Morphine, Safe as Aspirin
Japan's 132-mph Train Page 84
HANDSOME HOME PROJECTS:
Saturday Mechanic: Tune-Up Tips -
What Those New Grades Tell You About Plywood
An Amazing New Molding Rubber To Cast Plastics

> *A slight twinge of fear creeps through my body as I slip into the lukewarm water. I've heard that seven divers lost their lives exploring this very spring -- and in just four months four more will die in nearby Jenny Spring.*
>
> *But I push fear aside, as the hollow echo of my own underwater breathing fills my ear. Bob Roth, my diving partner, and I have spent hours rechecking gear. I'm confident. Bob gives the "thumbs up" sign. Mentally, I go over our diving checklist as we drift down to the cold bottom of Hornsby Spring. Everything seems okay.*
>
> *Though Bob and I have been diving in the wide-open sea for seven years, this is only the second year we've entered the dark, cold, restrictive world of "spelunk" diving in freshwater.*

> *We don't know it now, but four active college lads, having fun during the Christmas holidays, will run out of air, will panic and drown deep in the tangled, water filled caves of Jenny Spring.*
>
> *It's 10:34 a.m. My depth gauge shows 50 feet. Bob and I have decided to make an exploratory dive this morning. We just want to see the layout. Usually we take two air tanks, but now we carry only one apiece. We don't plan to stay down long.*
>
> *Hanging from Bob's waist is a spool of quarter-inch nylon cord. We'll use this as a guide rope.*

We'll stop the Popular Science story at this point, but note the ominous "Broken String" in the drawing.


Steel Net
TOPSOIL
LIMESTONE
Old String
LIMESTONE
Broken String
50'
20'
18'
60'
Farthest point of exploration
SILT
Ancient Bones
LIMESTONE
New Cord
15'
HORNSBY SPRING
Ancient Bones
SOFT SILT
Depth in feet
20'
30'
40'
50'
60'
70'
80'
90'
100'
110'
120'
Distance in feet
0
50'
100'
150'
200'
250'
300'
350'
400'
450'
500'
550'
600'
650'
700'
750'

The 1970s saw cylinders a third bigger, buoyancy compensating vests, compact safety reels, 30-watt lights, reliable pressure gauges and surveying improvements. Staging extra bottles extended the limits of exploration.

Beyond the technical definition of scuba -- but we'll include it as such -- is the "rebreather," a tank-like apparatus that provides a breathing gas containing oxygen and recycled exhaled gas. The closed circuitry makes the rebreather lighter and more compact than conventional open-circuit scuba.

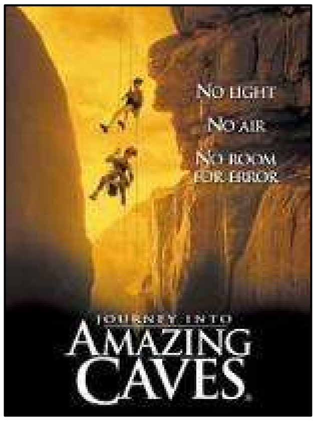
We can see the impact of improved scuba technology on cave passage penetration. With pools no longer the barrier they once were, cave explorers proceed ever deeper and further.

Year	Kilometers of explored cave passages
1970	10
1980	60
1990	100

More recently, video documentaries have introduced the world of cave diving to the viewing public.

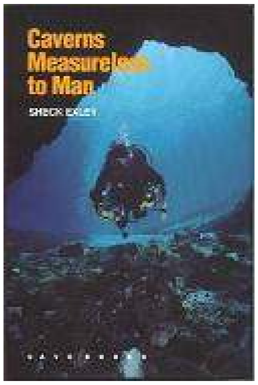
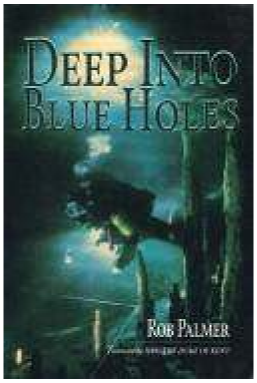
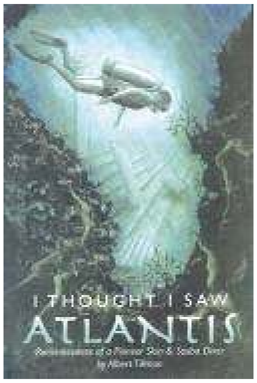
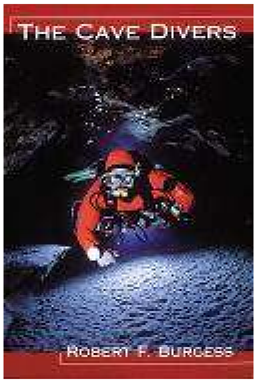
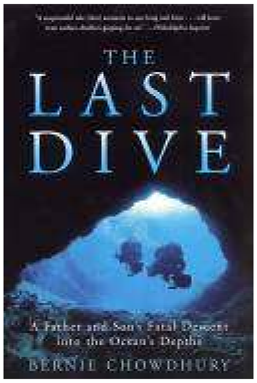
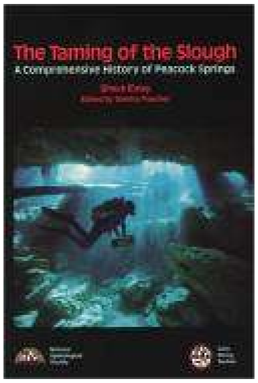
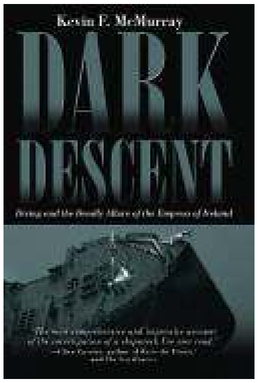
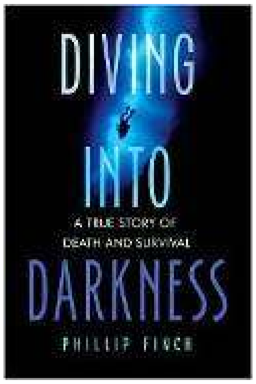
the hidden rivers of florida

PBS film series "Water's Journey" (2002)


NO LIGHT
NO AIR
NO ROOM FOR ERROR
JOURNEY INTO AMAZING CAVES

IMAX film, "Journey into Amazing Caves" (2000)

A few recent cave diving book covers,

 Caverns Measureless to Man SHECK EXLEY Sheck Exley* (1995)	 DEEP INTO BLUE HOLES ROB PALMER Rob Palmer (1997)	 I THOUGHT I SAW ATLANTIS Albert Tillman (1997)	 THE CAVE DIVERS ROBERT F. BURGESS Robert Burgess (1999)
 THE LAST DIVE A Father and Son's Fatal Descent into the Ocean's Depths BERNIE CHOWDHURY Bernie Chowdhury (2000)	 The Taming of the Slough A Comprehensive History of Peacock Springs Sheck Exley (2004)	 Kevin F. McMurray DARK DESCENT Kevin McMurray (2005)	 DIVING INTO DARKNESS A TRUE STORY OF DEATH AND SURVIVAL PHILLIP FINCH Phillip Finch (2008)

*Title from "Kubla Khan," Chapter 30, Down to a Sunless Sea. The author died at age 45, attempting to descend 300 meters in a Zacaton sinkhole, 30 meters less than the world record.

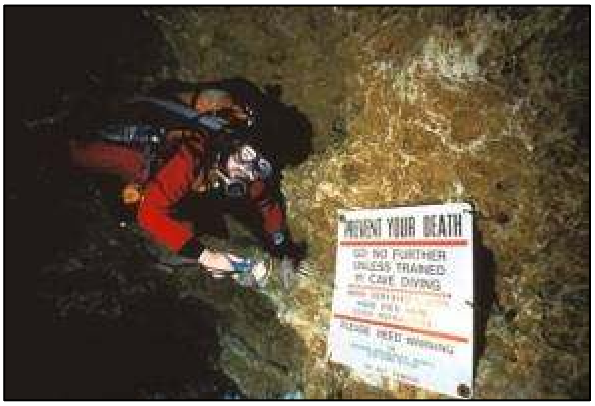
Diver Safety

The year 1974 was bad for cave divers -- 26 fatalities in the US alone. Safety has since improved, but there are still fatalities. Following is the National Speleological Society's compilation of American caving fatalities, 1994-2005.

Year	Location		Fatalities	Cause
1994	Sotano de San Augustin	Mexico	1	Lost consciousness, solo dive
	Zacaton	Mexico	1	Lost consciousness, deep dive
	Abaco Blue Hole	Bahamas	3	Out of air
	Convict Springs	Florida	2	Out of air
	Zoo Hole	Bahamas	2	Out of air, inadequate equipment
	Bakerton limestone mine	West Virginia	1	Equipment problem, rapid ascent
1995	Lake Apopka Cavern	Florida	2	Out of air, inadequate equipment
	Cenote Temple of Doom	Mexico	1	
	Devils Den	Alabama	1	Out of air, inexperience
	Thunderhole	Florida	1	Incorrect gas mixture
	Sharks Cove Lava Tube	Hawaii	1	Out of air, inexperience
1996	Paradise Springs	Florida	1	Silted out, no guideline
	Sea cave, Santa Cruz	California	1	
1997	Four Sharks Blue Hole	Bahamas	1	Narcosis
	Jackson Blue Spring	Florida	1	Embolism
1999	Wakulla Springs	Florida	1	Hypoxia
	Jackson Blue Spring	Florida	1	Siltation, out of air
	Diepolder Springs	Florida	1	Oxygen toxicity
	Madison Blue Spring	Florida	2	Lost guideline, out of air
	Forty Fathom Grotto	Florida	1	
2000	Little River Spring	Florida	1	Siltation, exceeded training
	Little River Spring	Florida	1	Inadequate equipment
	Poza de Juan Claro	Cuba	4	No guideline
	Cenote Sabak Ha	Mexico	1	Apparent heart attack
	Well in Goss Canyon	California	1	Bad air in gas pocket
	Ceita Core	Brazil	1	Deep diving
	Vortex Spring	Florida	1	
2001	Royal Springs	Florida	2	Inadequate equipment
	Cenote Escondido	Mexico	1	Inadequate equipment
	Clarksville Cave	New York	1	Stuck at constriction
	Andros Blue Hole	Bahamas	1	
	Emerald Sink	Florida	1	Inadequate equipment
	Devils Ear Spring	Florida	1	Out of air
	Ginnie Springs	Florida	1	Intoxication, no equipment
	Great Blue Hole	Belize	1	
	Jackson Blue Spring	Florida	1	
2002	Little River Spring	Florida	1	
	Devils Ear Spring	Florida	1	
	Orange Grove Sink	Florida	1	Heart attack
2003	Ocean Blue Hole	Bahamas	2	
	Cow Springs	Florida	1	
	Little River Spring	Florida	1	
	Roubidoux Spring	Missouri	1	Out of air
	Little River Spring	Florida	1	
2004	Nohoch Na Chich	Mexico	1	Contaminated gas
	Cenote Dos Ojos	Mexico	1	Contaminated gas
	Sea cave on Oahu	Hawaii	1	
	Resumidero El Oztoque	Mexico	1	
	Eagles Nest	Florida	2	Siltation, lost guideline, out of air
	Devils Ear	Florida	1	No guideline, out of air
	Sac Actun	Mexico	2	Lost, out of air
2005	Peacock Springs	Florida	1	Above certification, out of air
	Dogwood Spring	Florida	1	Inadequate equipment

The tabled average is 5 or 6 deaths a year. While a census of cave divers depends upon the definition of cave diving, estimates of the number of properly qualified and active cave divers tend to be in the 4000 range. The number of recreational scuba divers, on the other hand, is about 5 million, and the tabulation includes many of the latter population whose final dive was one for which they weren't qualified.

Little River, Florida sign, 1980s



Safer cave dives would be those in tested environments, an example being the former St. Joe Lead Mine, now the Bonne Terre Mine, Missouri. The facility has a diving platform, a half-million watts of lighting, and 24 dive trails. Diving is only in guided groups.

Bonne Terre
$23.00

Many divers, as we might expect, however, prefer passages more arduous and risky.

Northern Spain's Pozu del Xitu Cave is linked to Cueva Culiembro in the Rio Cares Gorge, "Europe's Grand Canyon," by a cave 15 kilometers long and 1,295 meters deep. As noted by explorer Chris Jewell in the August 16, 2010 MailOnline,

> *It's not just the diving but the bits in between that make it so arduous. Some of the trips underground lasted 15, even 18 hours. The water in the Picos caves is cold -- about seven degrees above freezing. That gives you maybe 40 minutes until the temperature stops you functioning.*

To traverse Pozu del Xitu, one must

Descend 37 vertical shafts as much as 140 meters deep,
Swim six sumps, and
Scale more than 100 meters of overhanging shafts and cascades by drilling expansion bolts into the rock.

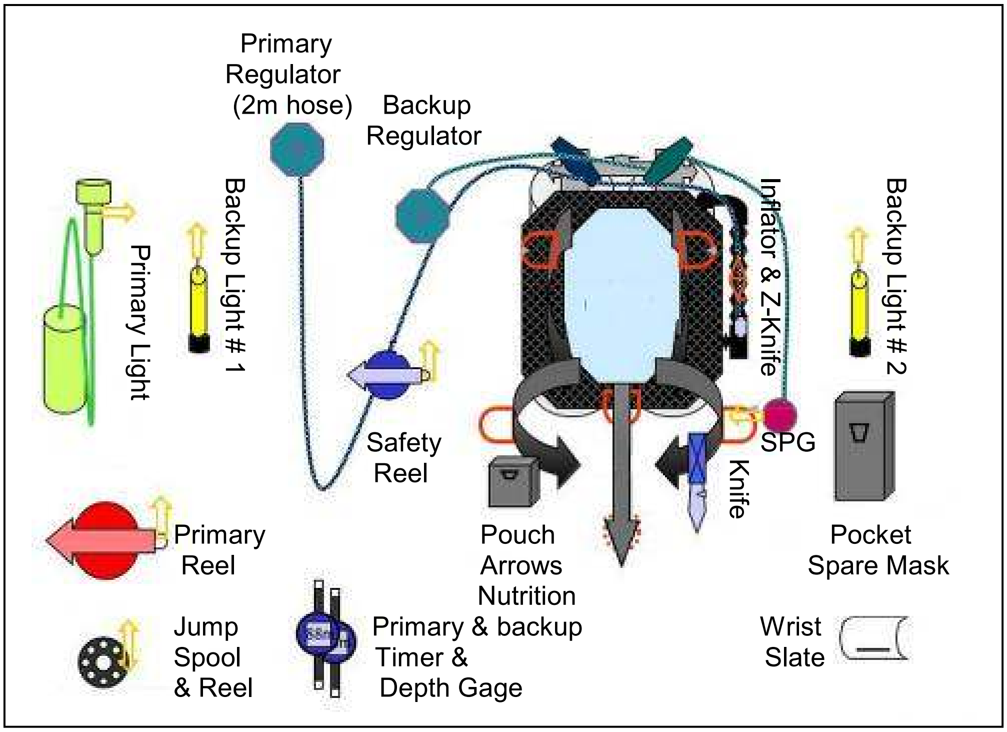
One can appreciate that danger derives from diver exhaustion as much as from hardware failure.

A few of the several organizations promoting cave diving safety:

The cardinal rules:

1. Be trained for cave diving, and remain within the limits of your training.
2. Maintain a continuous guideline to the cave exit.
3. Keep two thirds of your starting gas volume in reserve to exit the cave.
4: Remain within the safest possible operating limits for your breathing media.
5: Use three sources of light.

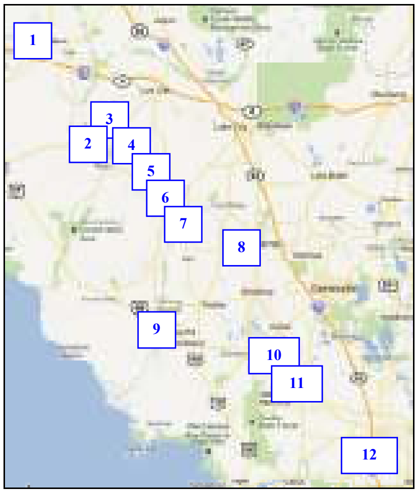
A safety equipment check list:


Primary Regulator (2m hose)
Backup Regulator
Primary Light
Backup Light # 1
Inflator & Z-Knife
Backup Light # 2
Safety Reel
SPG
Knife
Primary Reel
Pouch
Arrows
Nutrition
Pocket Spare Mask
Jump Spool & Reel
Primary & backup Timer & Depth Gage
Wrist Slate

Central to diving safety is diver certification. In a safety-assessment sense, "cavern diving" is the recreational exploration of overhead environments while remaining within sight of the entrances. Cavern divers generally venture no further than 40 meters below the surface and maintain a guideline.

"Cave diving," on the other hand, requires specialized equipment, e.g. a single gas supply feeding separate valves and regulator first stages. Should an O-ring rupture or a regulator begin to free flow, the diver can shut off the offending equipment and exit using the alternate regulator and valve.

An illustration of how particular sites can be restricted according to a diver's capability.



North Central Florida Dive Sites	pen Water Diving for any ertified diver	avern Diving for any ertified diver	avern Diving for certified avern diver only	ave Diving for certified cave iver only	Key
Madison Blue Spring	●		●	●	1
Telford Spring, El Dorado				●	2
Waterhole III				●	3
Peacock I			●	●	3
Peacock II					3
Peacock III				●	3
Olsen Sink				●	3
Orange Grove Sink			●	●	3
Cow Spring			●	●	4
Royal Spring				●	5
Troy Spring				●	6
Little River Spring			●	●	7
Ginnie Spring	●	●			8
Devils Eye and Ear	●		●	●	8
Manatee Spring	●		●	●	9
Catfish Hotel	●		●	●	9
Freidman Sink				●	9
Devil's Den	●	●			10
Blue Grotto	●	●			11
Paradise Spring		●			12

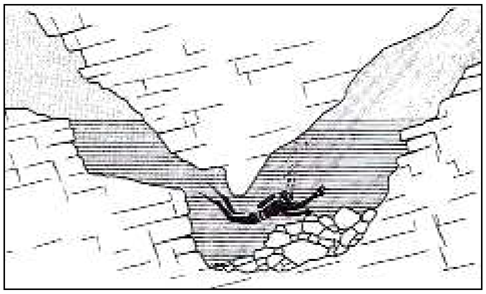
Certification's not inexpensive. Below are the training fees charged by a dive shop in Ginnie Springs.

Course	Days	Fee
Cavern Diver	2	$350
Cave Diver	2	$600
Stage Cave Diver Specialty	2	$600
Stage + TDI Extended Range	3	$600
DPV Cave Diver Specialty	2	$600
Extended Range Cave Diver	7	$2,100

"Using Revealed and Stated Preference Data to Estimate the Scope and Access Benefits Associated with Cave Diving," Resource and Energy Economics (33), 2011, by O. Ashton Morgan and William Huth, estimates the economic impact of a diver at Florida's Blue Springs to be $146 to $167 per trip, translating into a total impact of roughly $575,000 annually. Since the survey, however, the number of divers has doubled, raising the sum to something above $1 million.

Conclusion

Our plunge into cave diving has been mostly historical with a few safety warnings. We cited a few books for those wishing to read more, but it requires a visual experience to catch the underwater majesty. The fullest immersion, of course, requires just that, but this chapter's but one of many and we've not the time to properly certify. We wish not to take one of this year's five or six definitively-final cave dives.



CHAPTER 65

SUBTERRANEAN SHIPWRECKS

Having earlier devoted Chapter 49 to submarine boating, we should likewise recognize subterranean shipwrecks. We will visit five sites.

Mammoth Cave, Kentucky

We spent time at this wonder in Chapter 50, but we'll return to note an incident reported in the January 18, 1904, New York Times,

> *Tourists Near Death in Mammoth Cave -- Boat Carrying Eighteen Passengers Sinks In Echo River -- Coolness of a Guide and a Member of the Party Saves All from Drowning.*
>
> *Eighteen persons who came to this city to attend the convention for the National League of Commission Merchants are telling a story of a remarkable escape from death in the depths of Mammoth Cave. Only the coolness of their guide, John Nelson, and the courage of Charles A. Muehlbronner of Pittsburgh saved them.*
>
> *The party was composed principally of delegates from Chicago and the wives of some of them. Included in it were Mr. and Mrs. Muehlbronner and S.P. Craig of Pittsburgh, H.C. Rogers of Buffalo, and Miss Lucie Patch of Boston.*
>
> *The party started on the regular route through the cave, which included a journey in boats on the Echo River, the largest stream of water in the great underground passage.*
>
> *In going past some of these places the men and women in the boat were compelled to stoop far over in order to keep from striking the roof. It was while they were doing this at one point that the boat got beyond control of the guide for a moment and swerved toward a bank. The heads of the persons on that side were scraped by the roof, and they bent still lower.*

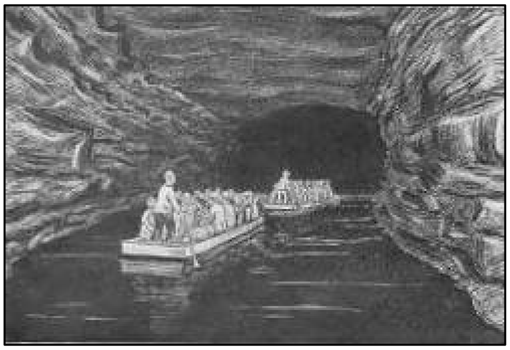
In a later account, one of the passengers was reported to have joked that the cavern roof should perhaps be raised to allow the next party additional headroom and then to have put his back against the roof as if to shove it up. Instead he pushed down the bow of boat and the rest of the story -- as they say -- is history. But back to the Times,

> *One side of the boat dipped into the water in consequence, and the craft began to fill.*
>
> *The guide saw the danger and called to Mr. Muehlbronner to jump and take the chain. This he did, landing on a steep bank, which offered only a slight foothold. Lying down on his face, he held to the chain and pulled the boat toward the bank.*
>
> *The boat sank in eight feet of water, but further back where there was no landing the water is eighteen feet deep.*
>
> *By the light of a single lantern the party escaped by climbing over Mr. Muehlbronner's prostrate form, and after waiting several hours for a boat, were brought in safety to daylight.*

By most accounts, however, it was the guide, John Nelson, who pulled the group to shore while Muehlbronner held the light and announced, "Attention! Do as the guide says, or none of us will get out of here alive."

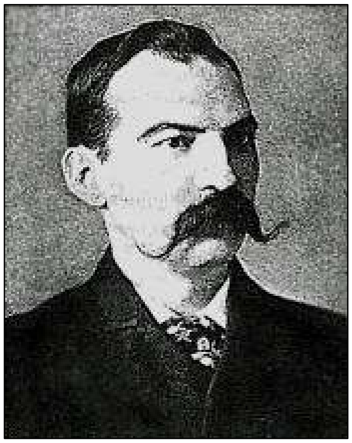
The account was run in the St. Louis Republic as "Thrilling Experience in Mammoth Cave." The Pittsburgh Gazette proclaimed, "Charles A. Muehlbronner Saves Seventeen Lives in Mammoth Cave."

The unfortunate vessel would have been one of the 20-passenger models introduced in the 1880s.



Returning to the Mammoth Cave Hotel, the grateful passengers formed the Echo River Club, Charles A. Muehlbronner, President for Life.

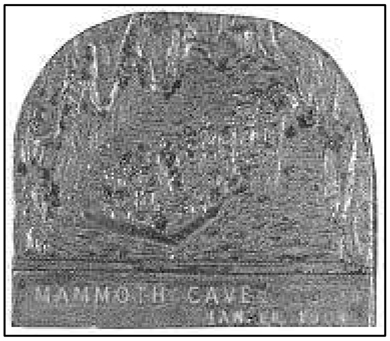
As for Mr. Muehlbronner -- the one who alerted the newspapers -- the honor was but one of many. Not only was he a leading merchant, banker and state senator, Muehlbronner was also a 32nd degree Mason, a noble of the Mystic Shrine, a member of the Independent Order of Odd Fellows, the Knights of Pythias, the Benevolent Protective Order of Elks and a contributing member of the German Lutheran Church.



The Echo River Club held annual reunions for several years. To the right is the silver medal presented to Nelson at the club's first anniversary.

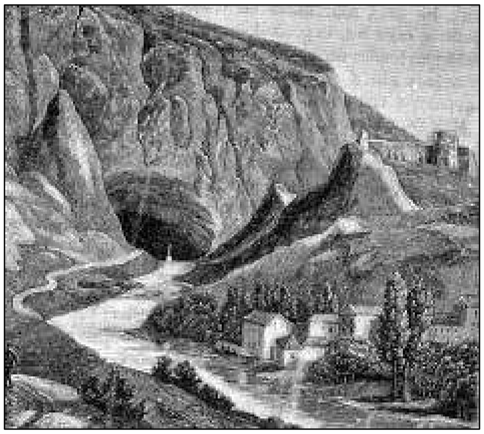
Nelson retired in 1907, having guided 4504 tours.

Horace Hovey, the era's authority on Mammoth Cave, changed the subsequent edition of his guidebook from, "The voyage is replete with pleasure" to "The voyage is usually replete with pleasure."



Fontaine de Vaucluse, France

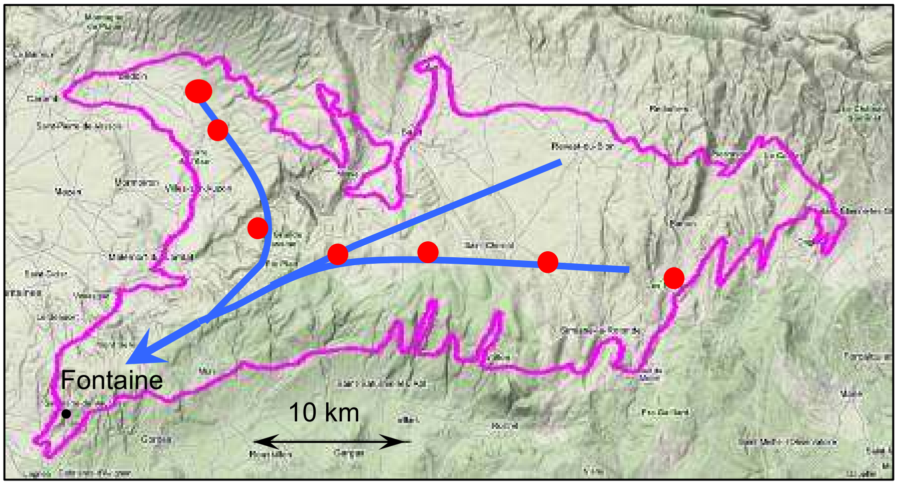
The Fontaine de Vaucluse issues from a collapsed cave system in the Côte d'Azuris. The water-filled shaft at the foot of a 240-meter cliff is the source of the River Sorgue.



1870

The spring discharges the entire runoff from 1200-square-kilometers of the Plateau de Vaucluse and the Vaucluse and Lure Mountains.

Red dots mark basin's major sinkholes, four of which exceed 500 meters in depth.



Low water

High Water

The water table, usually below the rim of the shaft, drains to springs in the riverbed, but after heavy rainfall, the water table rises and the fountain spills.

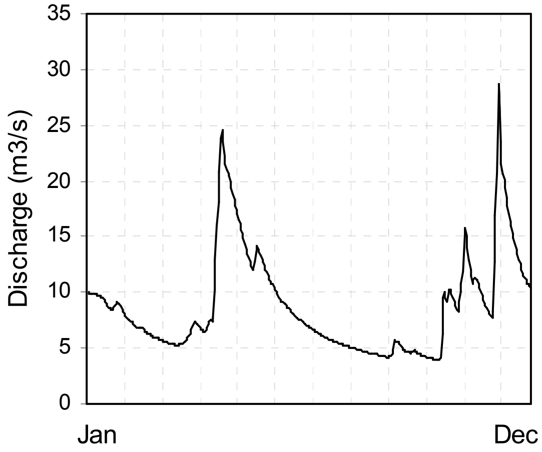
Average discharge is 22 meters/second, the highest in France, and can increase to 200 cubic meters/second after snowmelt and heavy rainfall.

World Record

Greatest Maximum Discharge

200 m^3/s

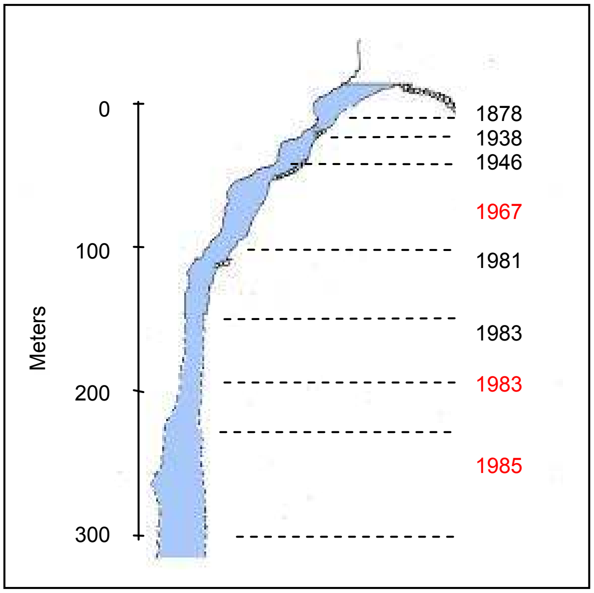
Daily flows, 2005, are shown to the right. Springflow derived from porous aquifers varies with season as a dampened and protracted hydrograph. Sharply-ascending spiked hydrographs indicate steep surface streams, or as in this case, lengthy subsurface conduits of large diameter.



The sketch indicates the galleries and approximate inclination of the spring. Sand closes the conduit at 308 meters, but the karst cavity likely continues far under the watershed.

From the sketch's scale we can compute a rough estimate of up-flow velocity. At typical conditions, the water ascends at perhaps a meter/minute. When discharge spikes, velocity increases proportionally.

The chronology of exploration is on the right because the Fontaine's exploration includes some notable events. Robotic endeavors are indicated in red.



Nello Ottonelli explored the upper 23 meters in 1878, dropping a zinc weight another 10 meters. A metal boat yet submerged beneath the surface is believed to have tethered Ottoneli's heavy diving equipment.

Jacques-Yves Cousteau
3,00F-0,60F 0,55€

Senor Negri thought he'd reached the bottom at 30 meters in 1938, a microphone in his helmet recording his observations.

Negri's claim was found to be erroneous, however, when in 1946, Jacques Cousteau (Chapter 64) and Frederic Dumas used scuba equipment to reach 46 meters. The two nearly died when carbon-monoxide from a diesel air compressor was sucked into the intake used to fill their aqualungs.

Reacting to divers' commercial interests, a 1974 municipal decree prohibited further explorations, but diving resumed in 1981 and Claude Touloumdjian reached 153 meters using a self-contained underwater breathing apparatus. In 1983, Jochen Hasenmayer reached 205 meters.

That same year, the wire-guided miniature submarine Sorgonaute I reached 245 meters, halted by lack of cable.

The following year was less productive, Sorgonaute II imploding at 233 meters.

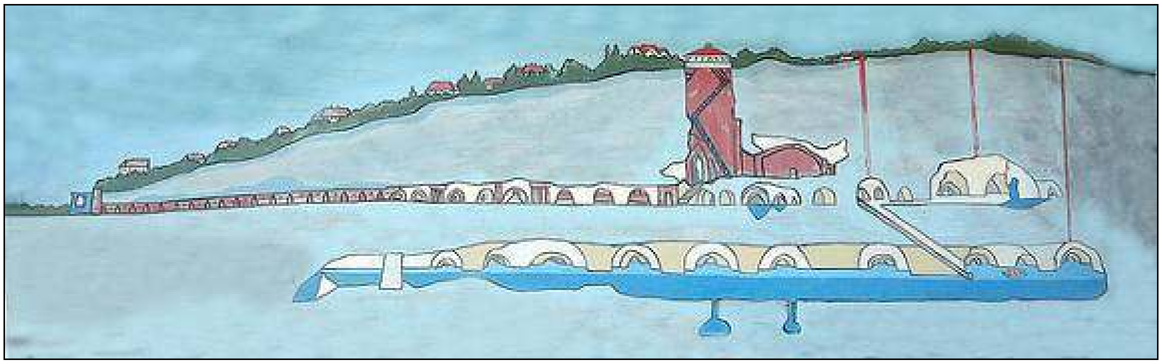
In 1985, a robot belonging to the Spelunking Society of Fontaine de Vaucluse hit sandy bottom at 308 meters.

Attempting to recover Sorgonaute II in 1986, Sorgonaute III was lost as well, leaving 150 meters of cable in the abyss. Two years later, Sorgonaute IV couldn't recover either of its predecessors. There are thus one metal rowboat and two submarines resting in the deep.

The Spelenaute's since become the sub of choice, but there remains need for a vehicle slim enough to enter the galleries at 135 meters noted by Cousteau.

Seegrotte, Hinterbruhl, Austria

Seegrotte's 6,200-square-meter underground lake came to be in 1912 when an accidental dynamite explosion flooded a gypsum mine with 20,000 cubic meters of water.



The Viking-like vessel that sailed under the Bastille in Disney's "The Three Musketeers" (1993) is moored in the tourist attraction of today.

Eintrittskarte
07013

Seegrotte
€9.00

But the grotto's history hasn't always been as Disneyesque.

During World War II, the former mine was dewatered to build military aircraft safe from Allied air raids. The world's first jet aircraft, the Heinkel HE 162, was built there by 1800 slave laborers, most of whom were killed just before the war's end. The Red Army destroyed the factory, but the cave remains.

And as for why we've included Seegrotte in this chapter, the tale's a sad one. In 2004, five tourists, including a German couple celebrating their golden wedding anniversary, drowned there after being trapped under their capsized catanmaran-converted-to-trimaran tour boat, just 150 meters from conclusion of the 45-minute excursion.

Falling into the water, some passengers held on to the boat, contributing to its overturn. The helmsman tried to right the boat, but the 1.5 ton craft was too heavy. Trapped beneath the hull for 45 minutes, the victims drowned in the chilly water.

Some 100 firemen, four divers, seven doctors and psychologists as well as a helicopter were rushed to the scene, but rescue efforts were hampered by the narrow width of the cavern.

"They probably didn't have much chance," said a police spokesman.

The starboard pontoon may have leaked and the passenger weight on that side was some 200 kilograms more than on the other. The tour operator and crew were sentenced to prison.

World Record

Subterranean Shipwreck Fatalities

5

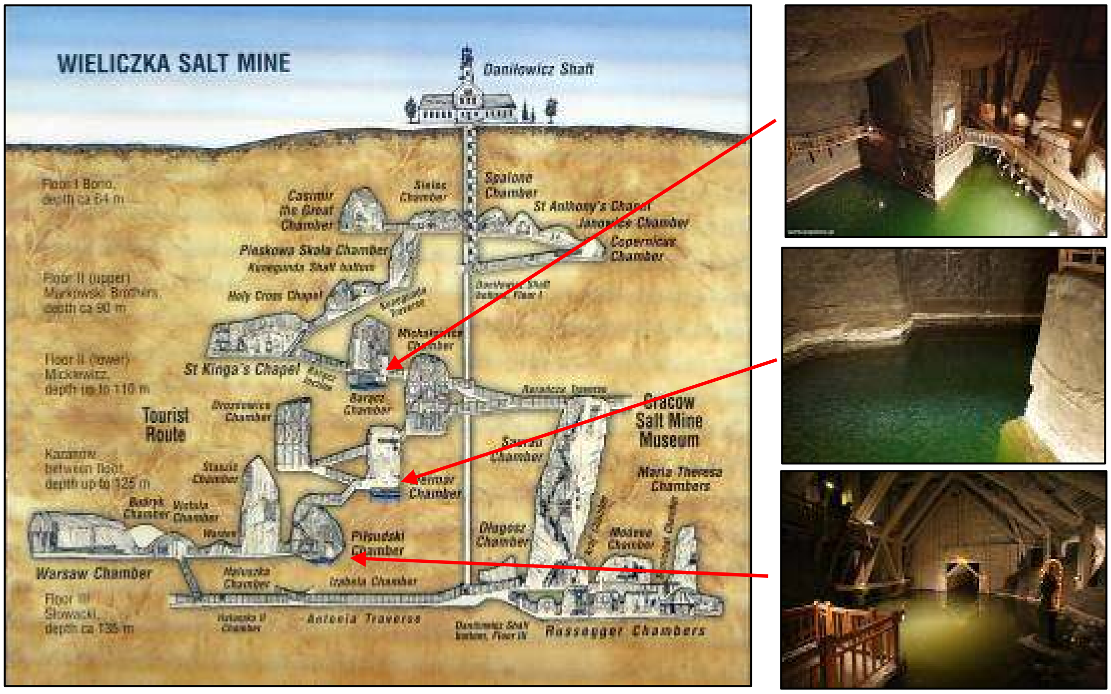
Im stillen Gedenken
31.Mai 2004
Seegrotte Hinterbrühl
Betriebsgesellschaft m.b.H

Unlike the dragon-headed Viking ship, however, this boat isn't on display.

Wieliczka Salt Mine, Poland

The Wieliczka mine produced salt for 700 years until it was fully converted to tourism in 1996. The mine is a UNESCO World Heritage Site because of its salt-crystal carvings of historic figures, mythical creatures and chapels with ornate chandeliers, many crafted by the miners themselves

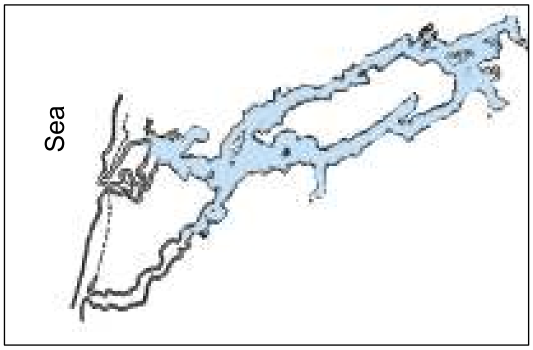
The mine operated tourist boats until 1919 when one capsized. The high concentration of salt water kept the victims -- the reported numbers differ -- afloat, but also prevented them from diving to escape. The pools are now lit with colored lights, but not navigated.

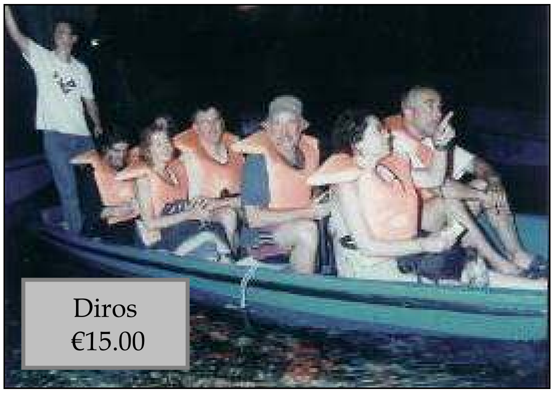

WIELICZKA SALT MINE
Danilowicz Shaft
Floor I Bono, depth ca 64 m
Casimir the Great Chamber
Sielec Chamber
Spalone Chamber
St Anthony's Chapel
Janowice Chamber
Copernicus Chamber
Pieskowa Skala Chamber
Kunegunda Shaft bottom
Floor II (upper) Markowski Brothers, depth ca 90 m
Holy Cross Chapel
Michalowice Chamber
Floor II (lower) Mickiewicz, depth up to 110 m
St Kinga's Chapel
Barqcz Chamber
Tourist Route
Drozdowice Chamber
Cracow Salt Mine Museum
Saurau Chamber
Maria Theresa Chambers
Kazanow between floor, depth up to 125 m
Stasic Chamber
Weimar Chamber
Budryk Chamber
Witold Chamber
Pilsudski Chamber
Dlugosz Chamber
Warsaw Chamber
Haluszka Chamber
Izabela Chamber
Floor III Slowacki, depth ca 135 m
Antonia Traverse
Rossegger Chambers

Diros, Peloponnesia, Greece

Lest the subject of subterranean shipwrecks quench our enthusiasm for boating in blackness, we'll conclude the topic with a visit to Greece.

There have been no subterranean shipwrecks in Diros Cave, but were there to be such an occurrence, note the safety features.

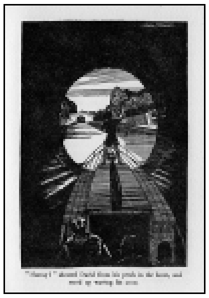




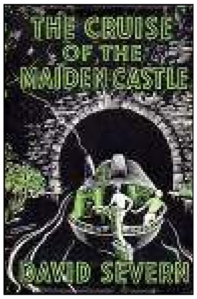
CHAPTER 66
MINEWATERS

We've traveled through mines in earlier chapters, the more recent being a pair of European mines, Seegrotte, Wieliczka, is search of subterranean shipwrecks. We'll visit more mines in chapters ahead. But here we'll consolidate the bulk of our hard-rock excursions. In at least a few cases, the hard-hat precaution has been relaxed for the tourists whose admission fees keep the mine open.

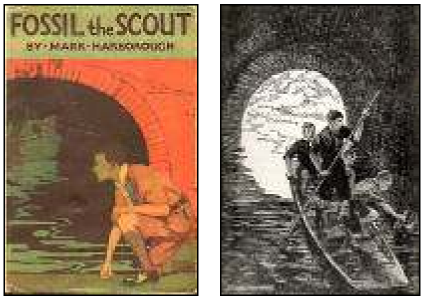
But before we proceed, let us tip our hats to the authors of British children's literature for their attention to boating into "adits," which as s British schoolchild would know, is a horizontal or nearly horizontal tunnel entrance. A few illustrations,



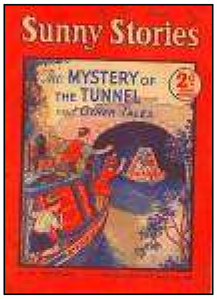
Explorers Afloat (1940) by Garry Hogg



Cruise of the Maiden Castle (1948) by David Severn



Fossil the Scout (1933) by Mark Harborough



"Mystery of the Tunnel," Sunny Stories, May 1954

Pb **Lead Mining**

We visited the Speedwell lead mine in Derbyshire as tourists in Chapter 51 and dove into Missouri's Bonne Terre Mine, Chapter 64, but there are many flooded lead mines, world-wide. We'll mention just two, both in England.

In Frost and Fire, Natural Engines, Tool-Marks and Chips, with Sketches Taken at Home and Abroad by a Traveler (1865), John F. Campbell describes a lead mine in Buckinghamshire.

> *In Park Mine, near Wrexham, the course of a subterranean river was cut in looking for lead. It can be got at by scrambling, and it is a curious place. A large cavern is water-marked from top to bottom, and old sand-beaches in passages mark a water-level fifty or sixty feet above the stream... In the bed of the stream are pebbles washed from a distance. A clear murmuring brook can he followed for a great way upstream; downstream it plunges into a hole, and disappears with a roar. It breaks into Minera Mine lower down, and where all the water goes at last no one seems to know or care, so that it is got rid of.*

And bringing us to the present, Moulds Level lead mine, North Yorks. The water would have been pumped out in its days of production and one could have traveled more than 10 kilometers underground.

Few hard-rock mines would merit such masonry, but when the value of the ore is high and the structural integrity of the overburden isn't, the shaft construction accordingly adjusts.

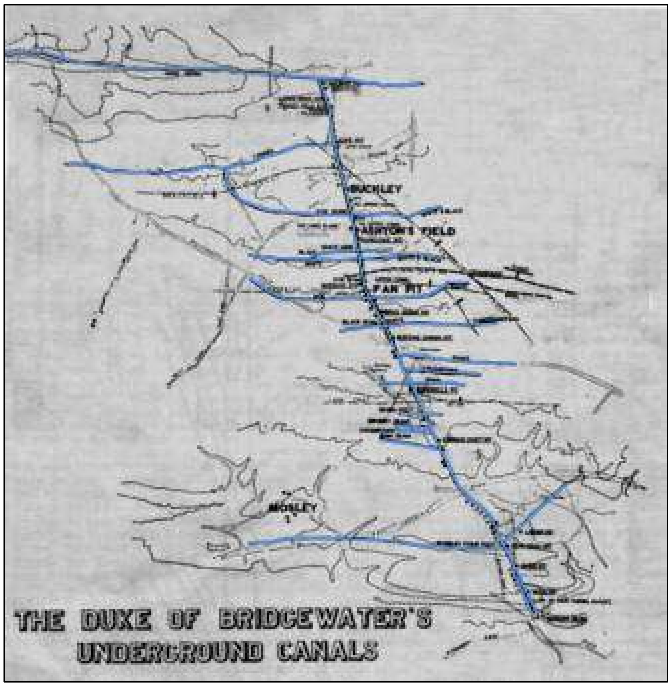
C Coal Mining

As can be seen in Winter Hill, Lancashire, coal mines tend to offer little in the way of aesthetic formations.

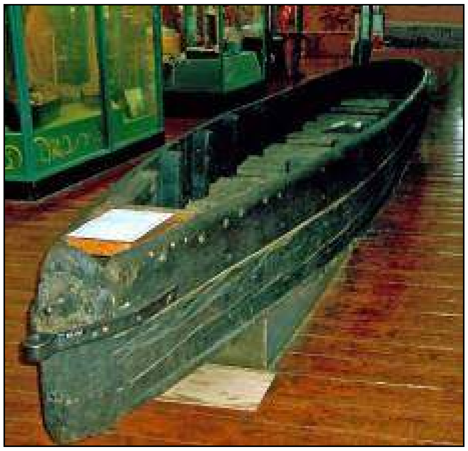
If there's a flooded portion, it tends to be a grimy inundation.

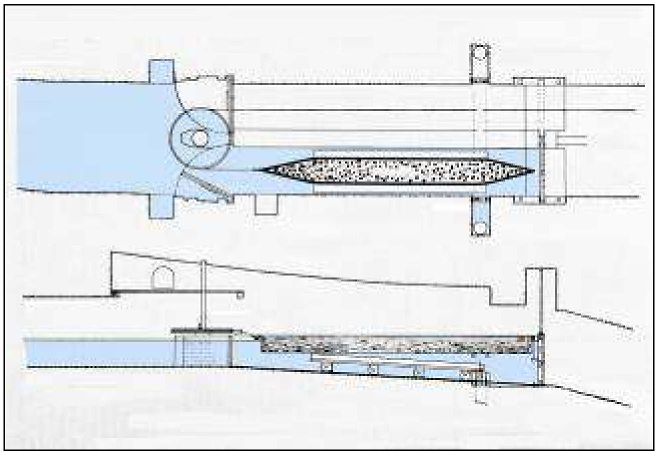
Evidence of coal mining near modern Manchester dates to the 14th century. Until the 18th century, extraction was primarily from shallow open pits, but increasing urban demand required more efficient production and transportation. The Bridgewater Canal from Booth's Bank to Worsley, and then to Manchester was completed in 1765.

Construction of an underground canal extending along the coal seam at the Worsley Mine began in 1759 and grew to 74 kilometers, serving coal faces on multiple levels.

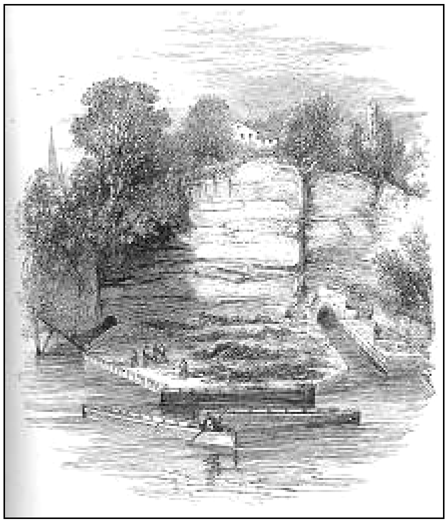


Miners boated to their place of work where their output was boxed into wooden or iron cases and loaded onto boats known as “starvationers” due to the crafts' pronounced ribs. The coal was boated out of the mines by means of subterranean locks and inclined planes, and then floated onward to Manchester. It was a forerunner of today's container shipping.





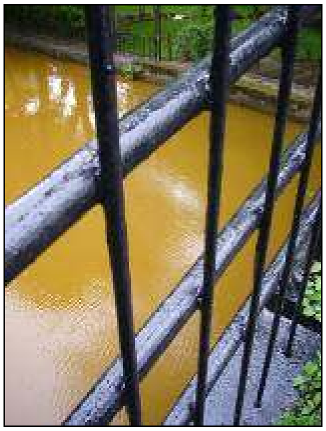
A railway line from Worsley to Wigan came to be in 1864 and use of the main-level canal for coal transport ended in 1887.



Left, "Worsley Basin and Starvationer Boats," Lives of the Engineers: Brindley and the Early Engineers (1874) by Samuel Smiles. The empty boats returning to the mine.

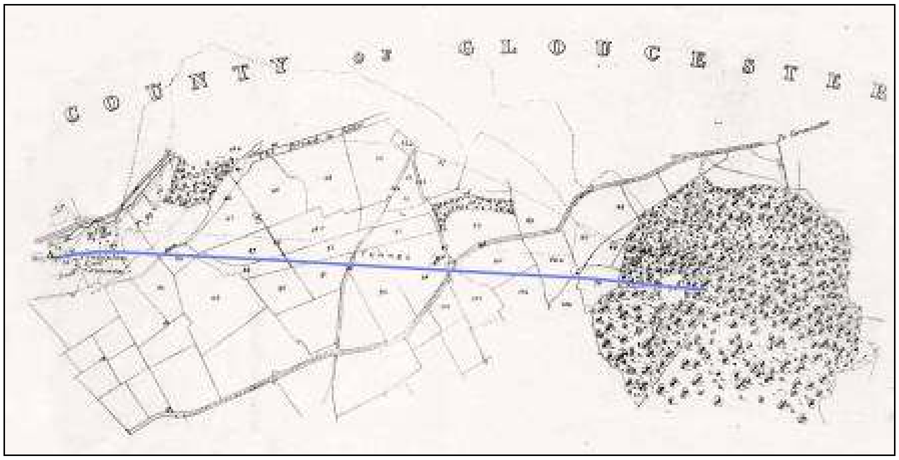
Above, Disused starvationers following closure of the mines, c. 1890

Today the mine is flooded. The distinctive orange water is due to iron salts leached from the penetrations. Efforts are ongoing to reduce the effluent's tint.



Although the Sapperton Tunnel is Gloucestershire is not a mine work, per se, we include it because it was constructed to transport a mine product, coal. Built at dead level through a limestone mountain in 1789, at 5 kilometers, Sapperton was the longest tunnel in the country.

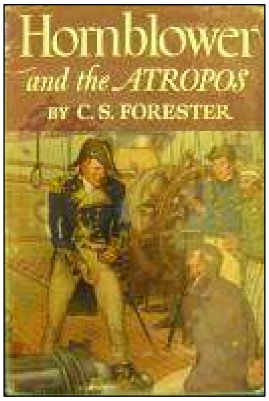
Below, a halfpenny token issued by the Thames and Severn Canal Co. in 1795 to pay wages to the workmen.



As described by William Bernard Cooke in The Thames (1811),

> *This tunnel was excavated in a direct line of two miles and a quarter though a variety of strata, though consisting chiefly of rock, underneath a hill, and presents a very novel and striking effect to those whose curiosity attracts them to visit it. A boat is kept in constant attendance for the purpose of entrance next to the village of Cotes.*

Set in 1806, C.S. Forester's Hornblower and the Atropos (1953) tells of Horatio Hornblower's canal boat experience after the boatman's assistant is incapacitated. A-third of the first chapter is devoted to the Sapperton tunnel. Lacking a towpath, boats were propelled through the passage by "legging."



A few lines,

> *And not far ahead was Sapperton Tunnel, the engineering marvel of the age, the greatest achievement of the new science. He certainly wanted to see that.*
>
> *The steersman pointed with his hook at the black forbidding tunnel mouth in the castellated entrance.*

> *"No tow path through the tunnel, o' course, Captain," he said "So we leaves our horses here an' we legs through. We puts a pair o' swings' on the bows — sort o' catheads, in a way. Charlie lies on one an' I lies on the other, wi' our heads inboard an' our feet agin the tunnel wall. Then we sort o' walks, and we gets the boat along that way, and we picks up another pair o' horses at the south end."*
>
> *It was obvious that it would be far easier to maintain gentle way on the boat than to progress in fits and starts of alternate stopping and moving. Hornblower hurried to the starboard-side wing and laid himself down on it as the bows of the boat crept into the dark tunnel. Lying on his right side, with his head inboard, he felt his feet come into contact with the brick lining of the tunnel. He pressed with his feet, and then by a simple backward walking motion he urged the boat along.*
>
> *A tunnel two miles long, driven through the solid rock of the Cotswolds! No wonder it was the marvel of the age. The Romans with all their aqueducts had achieved nothing to compare with this. Farther and farther into the tunnel they went, into darkness that increased in intensity, until it was frightfully, astonishingly dark, with the eye recording nothing at all, strain as it might. At their entrance into the tunnel the women had chattered and laughed, and had shouted to hear the echoes in the tunnel.*
>
> *So they went on through the darkness, in the strangest sort of mesmeric nightmare, suspended in utter blackness, utterly silent, for their speed was not sufficient to raise a ripple round the Queen Charlotte's bows. Hornblower went on thrusting with his feet, urging his aching legs into further efforts; he could tell by the sensations conveyed through the soles of his shoes that the tunnel was no longer brick-lined -- his feet pressed against naked rock, rough and irregular as the tunnellers' picks and gunpowder had left it.*
>
> *An underground spring here broke through the roof of the tunnel and tumbled roaring into the canal. The water fell down on them in deafening cataracts. It thundered upon the roofs of the cabins, quite drowning the cries of the women within. The weight of its impact pressed the tarpaulin upon him. Then the torrent eased, fell away to trickles, and then they were past it.*
>
> *His eyes were by now accustomed to the darkness, and in that massive darkness, incredibly far away, there was something to be seen, a minute something, the size apparently of a grain of sand. It was the farther mouth of the tunnel. He worked away with his legs with renewed vitality. The tunnel opening grew in size, from a grain of sand to a pea; it assumed the crescentic shape to be expected of it; it grew larger still, and with its growth the light increased in the tunnel by infinitesimal gradations, until Hornblower could see the dark surface of the water, the irregularities of the tunnel roof.*
>
> *It seemed unbelievable to Hornblower that he did not have to work his legs any more, that he was emerging into daylight, that no more underground springs would cascade upon him as he lay suffocating under a tarpaulin. The boat slowly slid out of the tunnel's mouth, and despite its slow progress, and despite the fact that outside the sun shone with only wintry brilliance, he was quite blinded for a while.*

Sapperton Tunnel was abandoned in 1927 and the water levels today fluctuate with the ground water. The clay canal bed is prone to rupture with ground water rise; the resultant holes release water when the ground water falls. Springs in the tunnel have been vented to outlets above the canal level, but even so, the pressure has been sufficient to lift and break the concrete lining. About 300 meters remain navigable.

But let us move on from England.

An unfortunate coal-mining event in Mexico, "Thirty-Five Miners Drowned," New York Times, January 3, 1898,

> *A dispatch from Guannajuta, Mexico, says that the San Puerta coal mine near there was flooded suddenly with water from an underground river, and thirty-five miners were drowned. The men were at work in one of the lower levels of the mine. There were no suspicions that an*

> *underground river existed anywhere in the vicinity of the mine, although that portion of the mine was exceedingly damp.*
>
> *The rush of water came without warning. There was a sharp crack like an explosion, the wall of coal and slate gave way, and before the men could seek safety on an upper level the rush of water followed, and the men were swallowed up almost before they could drop their tools. An expedition will be send into the mine as soon as possible to recover the bodies.*

One can be less morbid regarding coal mines and water, of course. Take, for example, "Five Men Trapped in 1935 Mining Disaster Emerge after 64 Years -- ALIVE & WELL!" Weekly World News, October 26, 1999.

> *Harrisburg Pa. -- The never-say-die heroes, who survived for decades by fishing from an underground lake, used primitive mining implements to tunnel their way out of a seemingly hopeless predicament.*
>
> *"It's truly a miracle," declared a physician who examined the hardy miners. "How these gentlemen survived more than 60 years underground is something we may never completely understand."*

As the astonished physician declared, truly a miracle!

Fe Iron Mining

The gates at the Magpie Sough iron mine in Derbyshire were used to increase the water level to float ore boats.

Au and Ag Gold and Silver Mining

Gold is precious enough that we'll give it a full chapter, Chapter 84, Underground Rivers of Gold. We'll include an Alaskan gold mine in this chapter, however, by virtue of its location in permafrost. From "Klondike Miners Tap a Swift Subterranean Stream," San Francisco Call, November 26, 1902,

> *Miners of Bonanza spent yesterday afternoon trying to save their buildings and shafts and the rich gold dumps from the most furious winter flood that has ever occurred in the Klondike. From a distance of more than 210 feet up through the rock and frozen clay of El Dorado Creek a gush of water is coming that is causing more excitement and threatens more damage than any similar phenomenon ever witnessed in the north.*
>
> *Yesterday at noon the men were down 210 feet. At that depth the ground was still frozen with ice that could be measured only by the lapse of centuries, and thawing machines and powder in plenty had to be used, the same as above ground.*
>
> *Yesterday the miners left for dinner and the steam thawers were hard at work. When the men returned they found water at the bottom, and the men who first descended had to return to the surface immediately to escape drowning. In six hours the shaft was filled to the brim. Then the overflow began to run down the hill. The torrent ran through part of the town of Bonanza,*

causing some damage by undermining small buildings and making a new stream to the main river.

HOMESTAKE GOLD MINE
LEAD, S. DAK

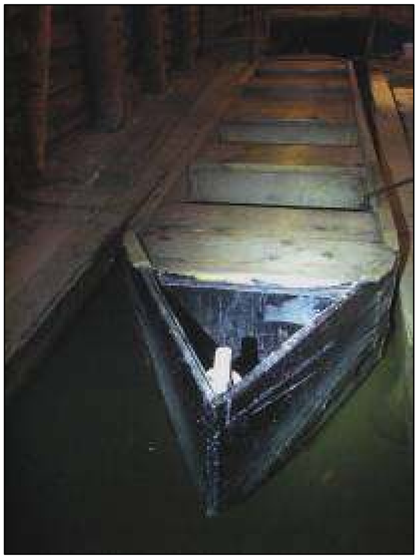
We've also an example from a silver mine that is unique. Case Western Reserve University's Large Underground Xenon dark-matter experiment is housed in the abandoned Homestake gold mine in Lead, South Dakota, the same cavern where the work of physicist Ray Davis gave rise to the solar neutrino problem in the 1950s. The photo shows Davis taking a dip in the pool surrounding his neutrino detector, 375 cubic meters of chlorine solution, 1.5 kilometers below the surface.

The medallion is Homestake silver.

Part of former silver mine in Tarnowskie Góry, Poland, the 600-meter Black Trout Adit was bored in 1821-1835 and still empties to the river.

To today's tourists 25 meters under the earth, the trout passing under their boats seem black because of the darkness, and thus the adit's name.

Black Trout Adit
27.00 PLN



Mining of copper, lead and silver began around Lautenthal, Germany in about 1225 and the number of mines reached 28 by 1690.

With the closure of the mines in 1959, the Glück Silver Mine was transformed into a museum in 1975.

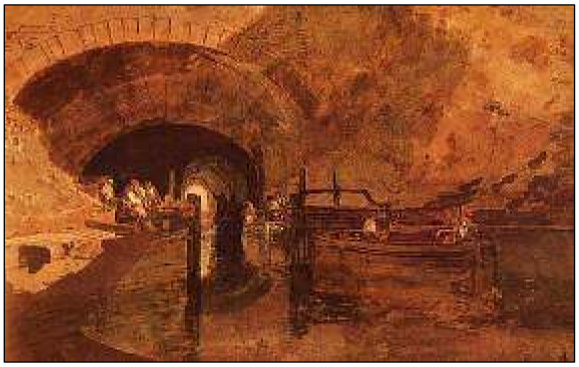
The tourist boats are patterned from the original ore boats, but for the added benches.

$\mathbf{Cu}$ Copper Mining

The area of Anglesey, Wales has been mined from the Bronze Age. Minerals in the copper mine pool to the right give it its red tint.

$\mathbf{CaCO_3}$ Limestone Quarrying

The Dudley Canal and Tunnel in the West Midlands was begun in 1775 to transport limestone extracted from the surrounding hills. At 2.9 kilometers, the tunnel remains the second longest in the UK canal network.

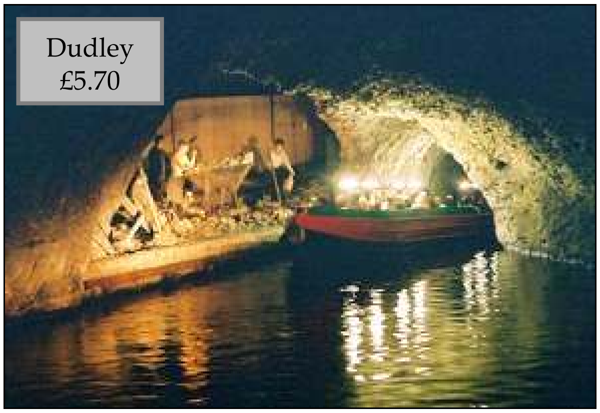


"A Canal Tunnel near Leeds" by English Romantic Painter, Joseph Mallord William Turner (1775-1851)

Restored in 1973, the canal forms part of the popular Stourport Ring narrowboat cruising route. A battery-powered vessel hauls tourists through the tunnel and adjacent mines.

1917 mine boat

Legging



NaCl **Salt Mining**

"Pinch of Salt," Putnam's Monthly Magazine of American Literature, Science and Art, December 1868, describes salt mining in Eastern Europe.

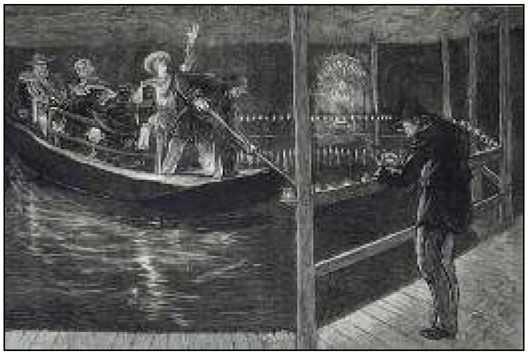
> *Gradually the passages become lower; the ceiling sinks more and more on the left, and at last the traveler is forced to bend, until he fairly creeps along on all fours. But suddenly he sees before him a fairy scene: dark waters, sparkling bright in the light of torches fastened to the glistening walls. Like a vast black mirror, the subterranean lake, silent and motionless, stretches far into the endless darkness. Never has wing of bird clipped its feathers into the mysterious water. Never has a breath of air ruffled its placid, patient surface.*

Salzburg means "salt town," and for that reason has been a trading hub along today's German-Austrian border. Several of the mines are open to tourists.

Hallein Salt Mine, also known as Salzbergwerk Dürrnberg, was worked by the Celts 2500 years ago. Today's 90-minute tour includes a boat ride.

Hallein
€9.50

Berchtesgaden salt mine has been in operation since 1517. The lake within the mine is 100 meters long and 40 meters wide.



Berchtesgaden, 1875

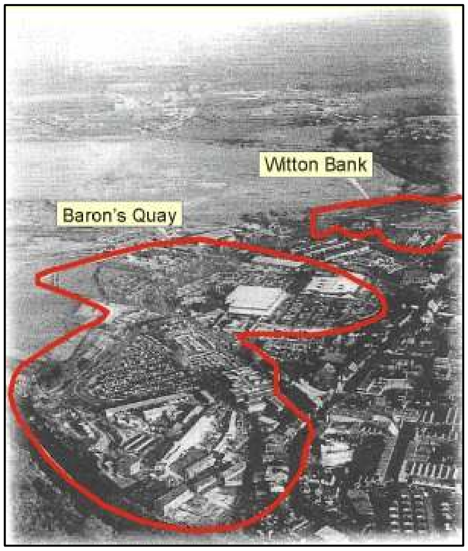
Berchtesgaden
€14.00

Nova Scotia's Malagash salt mine was opened after brine was discovered in a water well and mined until 1956. The photo is from 1944.

The Salina Turda salt mine in Transylvania is mentioned in records of 1075. The mine was closed in 1932, but since 1992 has been a halotherapy center and tourist attraction.

Chapter 40 dealt with karst sinkholes, by far the most pervasive land peril stemming from subterranean discharge, but not the only real estate peril if we include underground rivers created by mining.

The Northwich, Cheshire subterrain has been exploited for its salt since Roman times. When in the 19th century it became uneconomical to mine the salt, hot water was pumped through 15 hectares of abandoned shafts 100 meters below to dissolve the saline strata. The brine was pumped out and the salt extracted. This technique weakened the mine columns, however, and led to land subsidence as they failed. A surface major collapse occurred in 1880 when the River Weaver flowed into a subsidence pit.



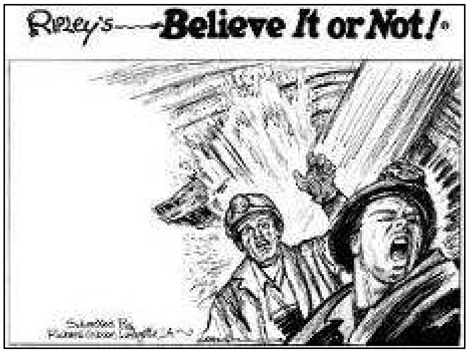
Advancements in mine stabilization are hoped to remedy the situation.

Texaco was exploring for petroleum beneath the floor of Lake Peigneur on November 20, 1980, while the Diamond Crystal Salt Company was excavating a cavity 400 meters beneath.

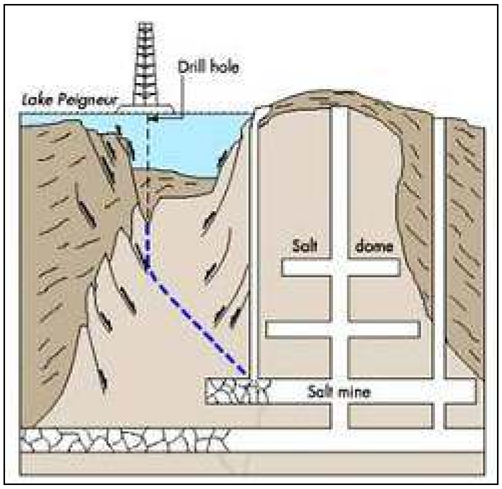
When the oil company's 36-centimeter drill bit punctured the mine cavern, the 50-meter rig dropped beneath the surface of a lake only 3 meters deep. As the aperture widened, the vortex pulled with it 11 barges, a tugboat and 26 hectares of forest. The drain became the state's tallest waterfall, 50 meters.

Flow in the lake's 20-kilometer canal to the Gulf reversed direction, a unique moment in history during which the Gulf of Mexico flowed north.

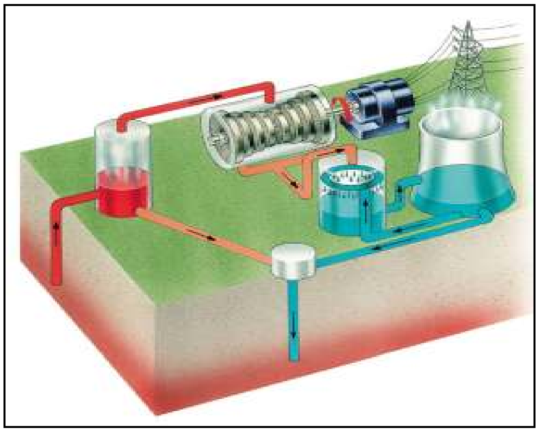
The downward flow displaced subterranean air that blasted out of the ground as a geyser 50 meters in height. Nine of the barges later popped out of the whirlpool.


Ripley's Believe It or Not!
Submitted By

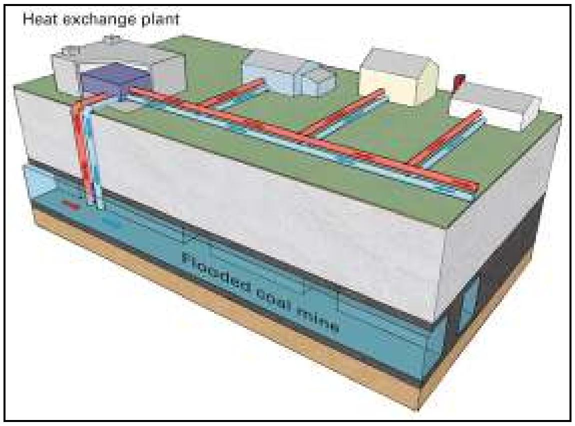
Oil drillers accidentally punched into a salt mine beneath Lake Peigneur, Louisiana in November 1980 and the resulting whirlpool sucked in a dozen boats and part of an island! -- May 28, 2006



Geothermal Energy



Geothermal water was discussed in Chapter 45, Subterranean Geophysics. While such energy can indeed be drawn from beneath the earth's surface, it's the temperature gradient, not the water, per se, that produces the power.



Above, a scheme for using the water from a flooded Ohio coal mine to heat and cool buildings on the surface by means of a heat pump. Heat extracted from the minewater is used to heat buildings in the winter and the cycle is reversed during warmer periods.

Morbidity

Mining is a dangerous occupation, but to what degree is water the agent of death? First we'll look at a few morbid examples where it is and then we'll look at the broader statistics.

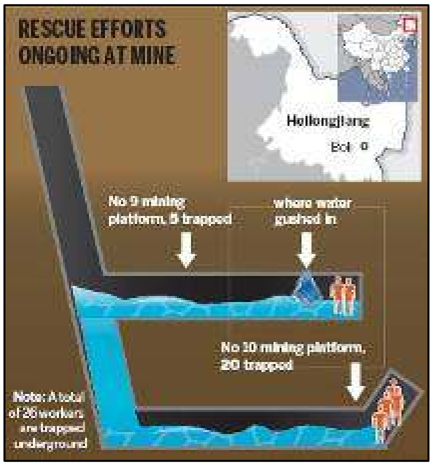
During an unusually-heavy 75-minute thunderstorm at Cornwall's East Wheal Rose lead mine in 1846, water was rushing down the hills within five minutes. Despite efforts to divert the flood from the shafts, the mine was rapidly flooded to the 100-meter level and of the 200 miners underground, 39 drowned.

From "Subterranean Stream Trapped 350 Miners. One Report Says All Have Perished -- Nine Bodies Recovered," Geneva [New York] Daily Times, March 3, 1914,

> *Brussels. Three hundred and fifty coal miners were trapped today by a rush of waters to a mine in the province of Hainaut, when a subterranean stream burst through the walls of one of the chambers. Within a few hours the bodies of nine men had been recovered. The danger alarm was sounded as soon as the inflow of water began. Many miners were able to reach the surface, but many were cut off and their fate is unknown.*

The Wangjialing coal mine in China's Shanxi province was flooded on March 28, 2010 when workers broke into an abandoned water-filled shaft. Over 100 miners managed to escape, but 153 were trapped in nine different platforms.

Twenty-two the 26 miners were rescued from the Qitaihe coal mine in Heilongjiang province on August 30, 2011, seven days after being trapped when 40,000 cubic meters of water gushed into the pit.


RESCUE EFFORTS ONGOING AT MINE
Heilongjiang
Boli
No 9 mining platform, 6 trapped
where water gushed in
No 10 mining platform, 20 trapped
Note: A total of 26 workers are trapped underground

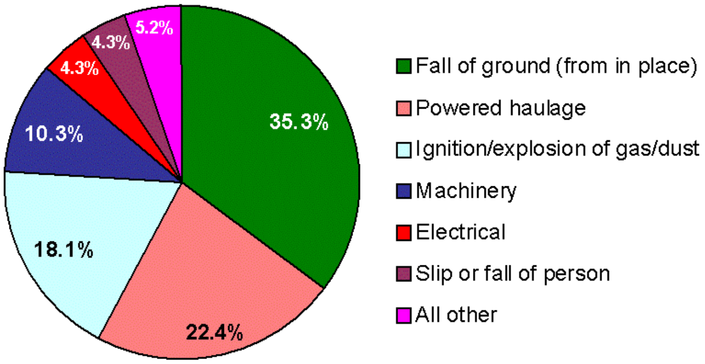
Graphic from CCTV

Note the last sentence in the June 24, 2002 Associated Press dispatch.

> *Accidents in China's mines have killed 3,393 people this year, the official Xinhua News Agency reported Monday. The figure puts the notoriously deadly industry on track to match or exceed last year's toll of 5,670 deaths despite repeated attempts to boost safety and close hazardous mines. Most mining deaths are caused by explosions of gas pockets and floods caused by the breaching of underground rivers.*

But such deaths are much rarer in the United States, as evidenced by chart of deaths in underground mining fatalities, 2003-2007, of which there were 116.

Drowning may comprise some portion of one or two of the lesser categories, but the number is small.



A 1997 Mine Safety and Health Administration alert sheds additional light on the subject. Of the 23 drowning deaths at mining (including dredging) sites in the United States, 1990-1997,

12 were due by mining equipment falling into water.
10 were due to individuals falling into water.
1 was while swimming from the shore.

12 were at a quarry or strip-mining operation.
10 were at dredging operations.
1 was at a mill.
0 were underground

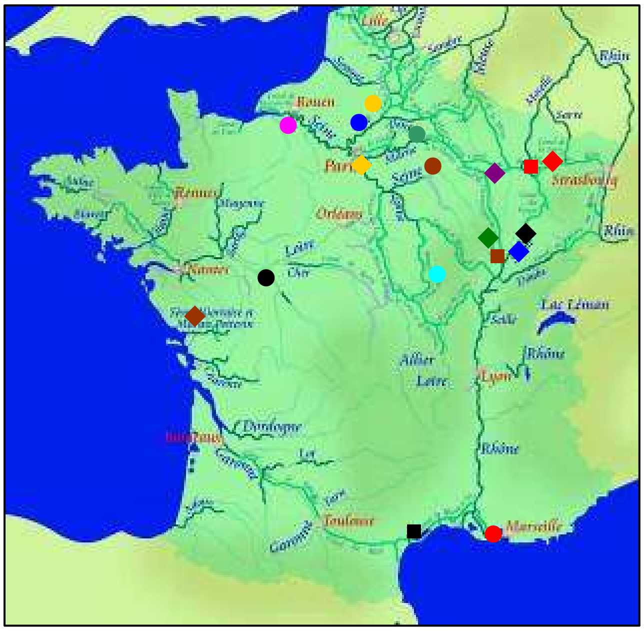
Minewaters have historically been the cause of massive tragedy and the danger is only now -- we can hope -- being mitigated in many parts of the world. Minewaters in the United States, however, have become less lethal.

CHAPTER 67
TUNNELS DU CANAL

In the previous chapter we toured British canal tunnels once associated with mining. Now we will cross the Channel to France and its 40-plus canal tunnels constructed for commodity transport, the aggregate length of which was nearly 30 kilometers by the mid-1800s. We'll visit the underground waterways exceeding 1000 meters in length, and then a few of the shorter ones.

Canal Tunnel Locations

- ● Tronquoy, Riqueval
- ● Ruyalcourt, Panneterie
- ● Saint Aignan
- ● Braye
- ● Billy le Grand
- ◆ Liverdon
- ■ Foug
- ◆ Saint Martin
- ◆ Mauvages
- ◆ Arzviller
- ◆ Chérimont
- ◆ Saint Albin
- ● Pouilly
- ■ Besancon
- ● Balesmes
- ◆ Saint Léonard
- ● Rove
- ■ Malpas


Lille
Somme
Rouen
Seine
Paris
Marne
Meuse
Moselle
Rhin
Sarre
Strasbourg
Rennes
Mayenne
Orléans
Loire
Nantes
Cher
Saône
Lac Léman
Allier
Loire
Rhône
Lyon
Dordogne
Lot
Garonne
Toulouse
Marseille

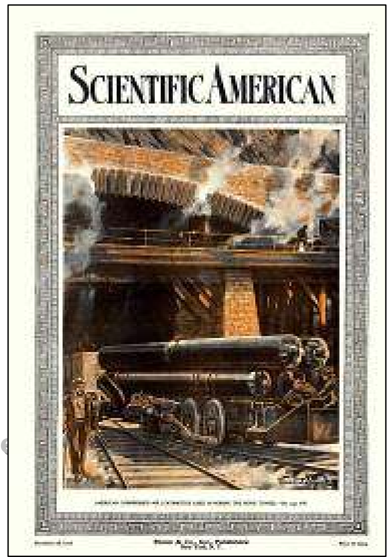
Rove Tunnel, Marseilles-Rhône Canal

Length: 7,120 meters. Width: 22-meters, sufficient to cross two 1500-ton barges. Height: 15 meters, 4 of which are below the water line.

World Record
Longest Navigable Canal Tunnel
7,120 meters

The idea of a canal connecting Marseilles to the Rhone was advanced from the 17th century, but it wasn't until 1911 that work began on the Rove, linking Marseilles Harbor to Berre Lake, a salt water body. The project employed 3000 workers, mostly Spanish and Italian immigrants and German prisoners of war. As two 70-ton American steam shovels did not prove satisfactory, much of the excavation was by jackhammer and blasting.

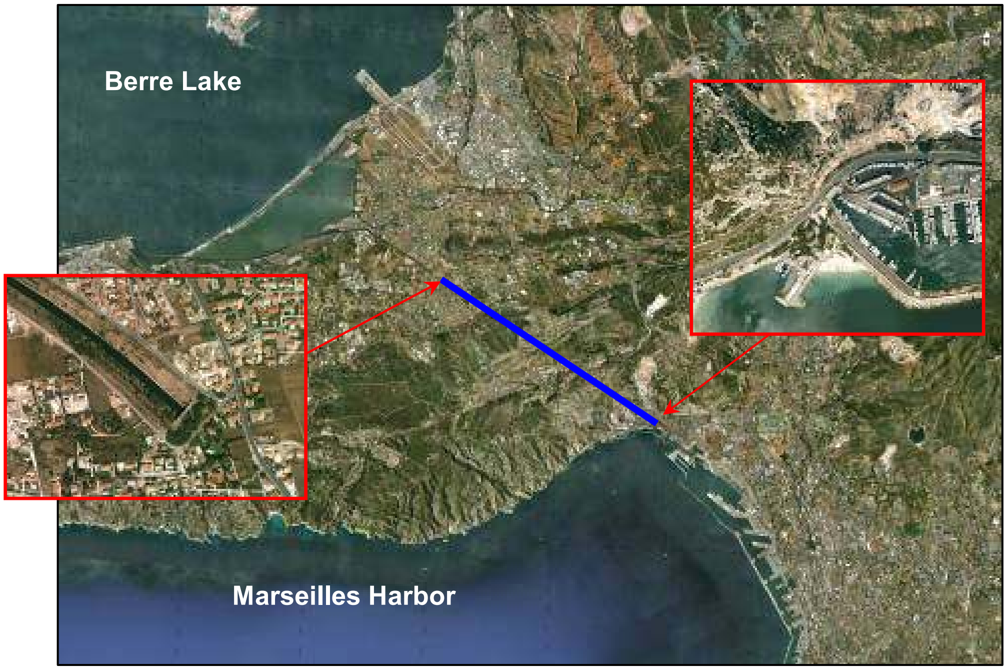
To the right, "American compressed air locomotive used in boring the Rove Tunnel," Scientific American, November 25, 1916.

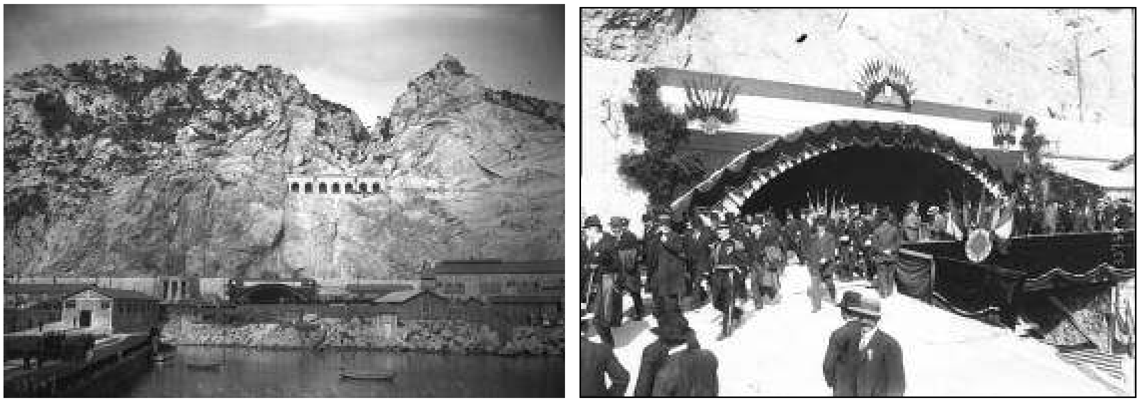

SCIENTIFIC AMERICAN

At the time of construction, Rove was the world's largest tunnel, in terms of excavation. The project was said to be one of the greatest pieces of engineering since the Panama Canal.

Former World Record
Greatest Tunnel
Excavation
2,500,000 cubic meters

The tunnel was opened to barge traffic in 1926.





Above, photos from 1913. Note the cofferdam at the tunnel mouth and the multi-arched structure along the cliff above. We'll return to it later. The second photo documents an official visit.

1916

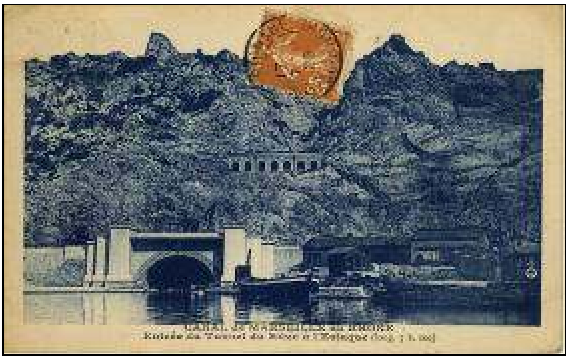
1920. The tunnel opened seven years later.

1933

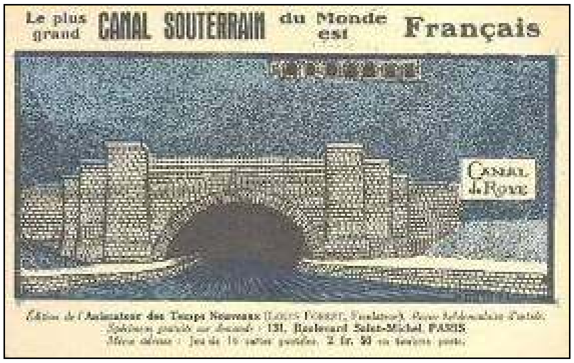
Today

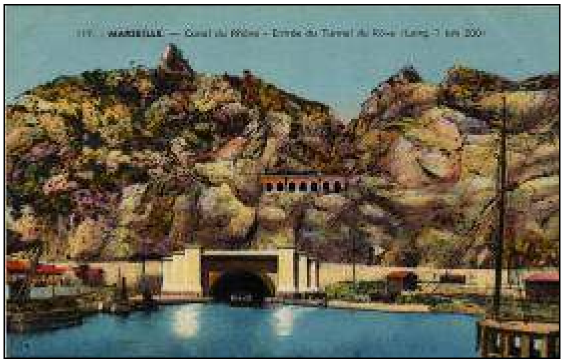
Chapter 50 included decades of fairly-similar postcards showing Mammoth Cave's Echo River, far more photographs than needed to simply illustrate the physical water. The many postcards illustrate how the idea of an underground river continues to intrigue.

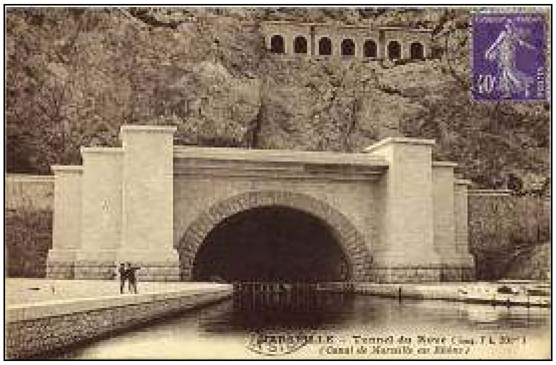
Attention to the Rove was similar, as illustrated by postcards of the entrance from the Marseilles marina,



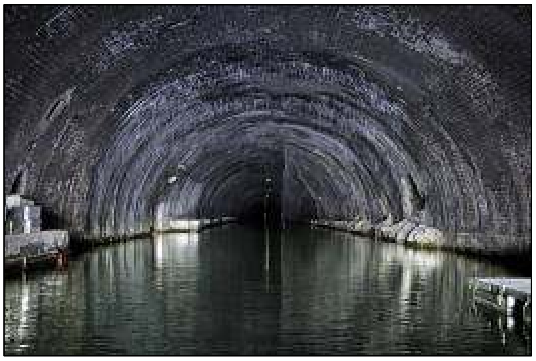
..


Le plus grand CANAL SOUTERRAIN du Monde est Français
Canal du Rove





In 1963, 200 meters of roof collapsed at roughly the tunnel's midpoint, leaving a 15-meter crater on the land surface. The Rove has since been closed to all traffic.

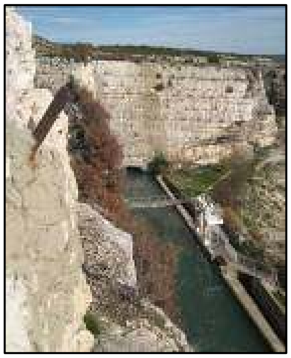


Today's traffic-free interior.

There is effort to bring the tunnel back to life as water supply for the eutrophic Berre Lake. A bypass pipe through the blockage is scheduled to be constructed in 2013.

The multi-arched structure above the Rove entrance is a portion of the Roquefavour Aqueduct, a structure more known for its 393-meter span a few kilometers to the north. There's something else notable at that site, a 200-meter canal tunnel feeding the aqueduct, a subterranean waterway becoming aerial.

Looking upstream from the aqueduct



Looking downstream from the tunnel

Riqueval Tunnel, Canal de Saint-Quentin

Length: 5,670 meters. Width: 6.6 meters after one of the towpaths was removed in 1861.

Acclaimed as the "Grand Souterrain," the Riqueval was inaugurated by Napoleon in 1810

In his Through France and Belgium by River and Canal in the Steam Yacht "Ytene" (1876), William Moens recounts a tale from that time.

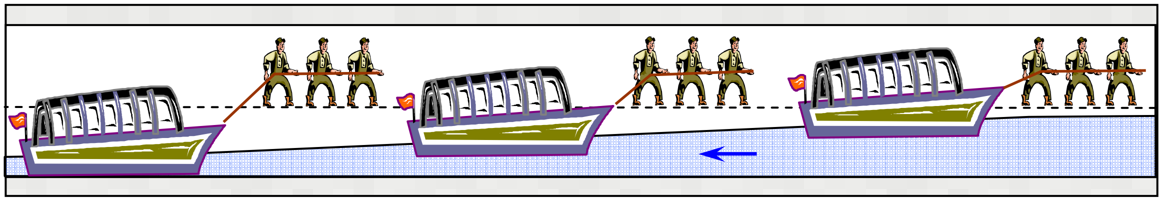
> *When the tunnel was first made, nothing would induce the men working the barges to use it, so great was their dread of it; but a reward offered by the administration, to free the first barge that went through it from tolls forever, soon brought forward a volunteer, whose barge is still in use, and in a good state, though it has been so repaired from time to time that probably little of the old vessel remains.*

Barges were initially hauled by 7 or 8 men from towpaths on either side of the channel, a 12 to 20-hour endeavor. The Annual Report of the Chief of Engineers to the Secretary of War (1876) contains a translation of Annales des Ponts et Chausseés (1863) by M. Lermoyez regarding a hydraulic difficulty.

> *The nature of the work obligates boats to navigate in fleets or convoys, because they cannot pass each other, not only in the tunnels, but also in the narrow portions of the trunk between*

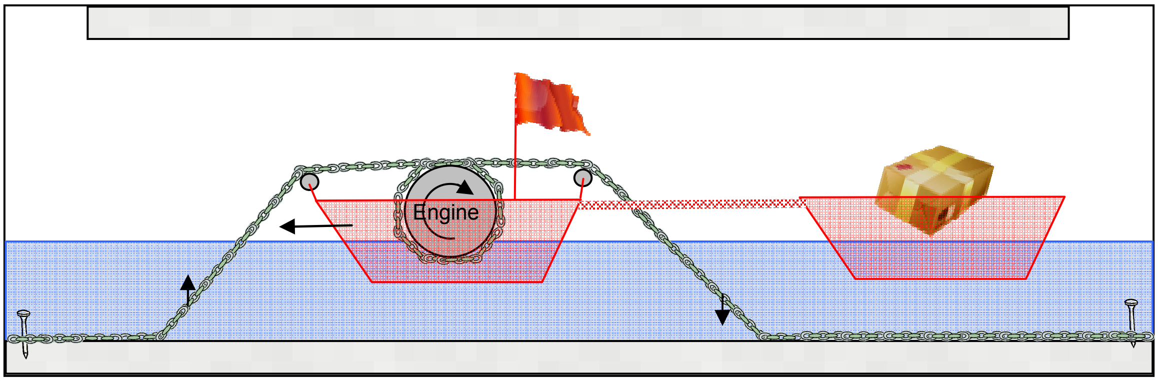
them. Consequently when a fleet entered the tunnel it formed a long piston and drove the water before it, as the flow along the sides was insufficient, since a space of only 8 inches was left between the sides of the boats and of the walls of the tow-paths. The wave thus driven forward by the fleet, spread in the level, and advanced rapidly until it met an obstacle which compelled it to retrace its steps; it then came back, re-entered the tunnel, where it caused a current opposed to the course of the fleet, stopped the boats, and created a resistance that the haulers were unable to overcome. The latter, when the wave came, instead of exhausting themselves in useless efforts to overcome it, contented themselves with preventing their boats from going backwards, and only resumed their march after an equilibrium had been established.

This movement of the waters caused an appreciable lowering of the water surface at the end of the fleet, and formed a veritable incline which the boats were compelled to ascend. The difference in level, which was nearly half an inch per boat, became so great for long fleets that the last boat of the convoy had not sufficient water to float it, and became stranded on the bottom of the canal.

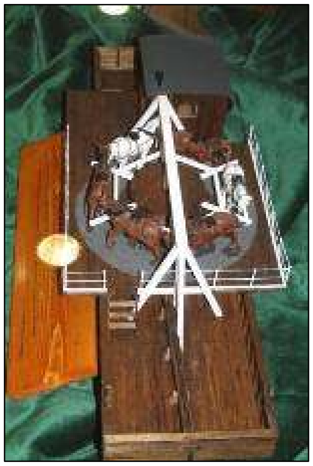


Horses were later used, but time of transit was in fact increased due to the additional resistance on ever larger barges.

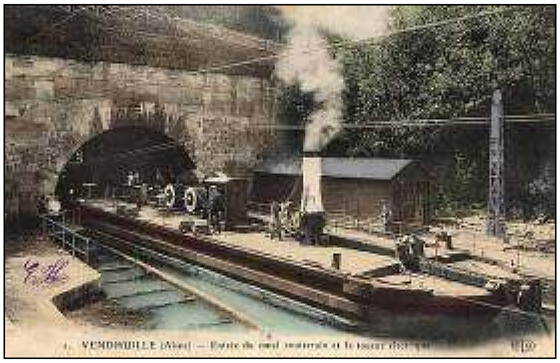
Enter the chain tugboat ("toueur"), a vessel that hauls itself along a heavy chain pinned at each end of the channel floor and integral to the boat in both directions. Adhesion is obtained by several windings on a capstan located at the vessel's midpoint. As the craft can not turn around, the bow and stern are identical.

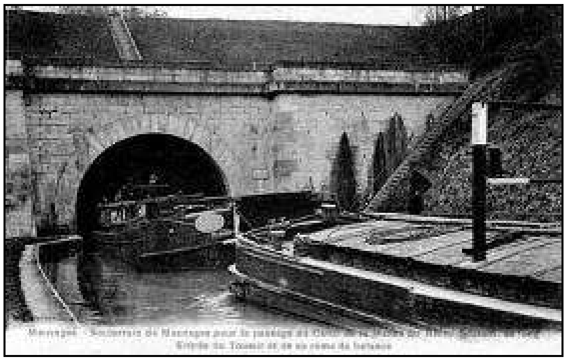


The canal's first chain tugboat, Le Rougaillou, was powered by eight horses plodding carousel-style on the deck to rotate the capstan.



Steam-powered chain tugboats introduced in 1867 allowed up to 35 vessels to progress at 1.1 kilometers/hour. Passengers were subjected to heavy smoke. As the boat train impeded canal outflow, the water level rose within in the tunnel by 25 to 45 centimeters and it took up to an hour to drain this impoundment.



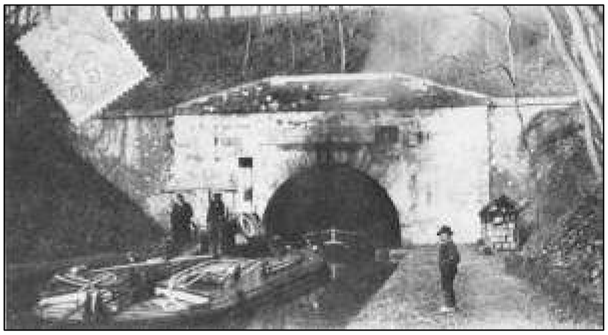


Moens recalls his steam-era experience.

> *Three miles ahead was the long tunnel of Riqueval, which the men in the barges expected to be six hours in going through.*
>
> *Night had now come on; it was pitch dark and raining hard, and were we to remain where we were* [in the queue]*, we might, too, have to pass six hours in the bowels of the earth, with the atmosphere in a charming state, from the smoke of the tug steamer, to say nothing of the thirty odd fires of the barges moving slowly behind it. I quickly made up my mind to pass them all, and became the leading vessel instead of the hindmost... We gradually passed them all, and reached the entrance, mooring the Ytene just ahead of them all...*
>
> *Suddenly, at about nine o'clock, we heard a great outcry in the tunnel, and men came running along the towing path, asking if we had a pump. We said yes, several, but not movable; and they explained that one of the barges had struck violently against a stone in the side of the tunnel and had been stove in, and there was a great fear lest she should sink in the tunnel itself with the 270 tons of coal with which she was laden. This was a pretty state of things, and we soon thought that our route to Belgium would be barred fro weeks and that we might have to retrace our way back again. The tug steamer soon, however, emerged from the arch, and came to a standstill where three or four barges were out of the tunnel. It was the first that was injured, and she was already sunk to within three or four inches of the gunwale.*
>
> *Long planks were soon put out to the shore and a crowd of excited Frenchmen assembled, each with a large galvanized pump borrowed from the barges behind us. They were all soon at work pumping... It was a curious and exciting sight, all those collected together having large lanterns with them; loud and hurried orders being heard from those in charge...*
>
> *I ordered my men to go on board and assist at the work, and at last, after great exertions, it was found that the vessel did not sink deeper in the canal, and after some time the pumps,*

> *increased in number, began to gain on the water, and the hole was discovered in her starboard bow. There had formerly been a towing path on each side of the tunnel, but it had been found that the water space was not wide enough, that on the left hand was cut away, but leaving rough stones and projections against one of the unfortunate vessels had struck, being towed at too rapid a pace by the tug. Some planks and nails were obtained and I contributed some cotton waste, and after some work the leak was stopped.*
>
> *It was half-past twelve o'clock before we turned in, the occurrence that had just happened not tending to cheer us, or to make more pleasant the prospect of going through the tunnel, which was nearly four miles long, and the sides of which were not as smooth as one could wish.*

By 1878, up to 110 barges were traversing the Riqueval on a daily basis.

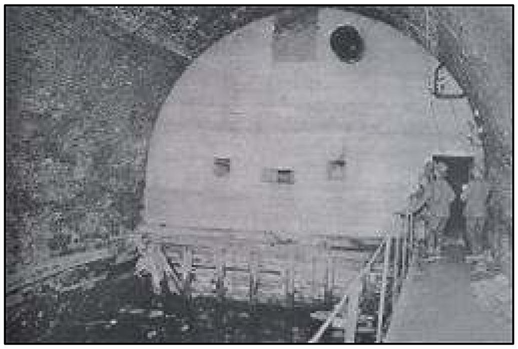


Turn of the century

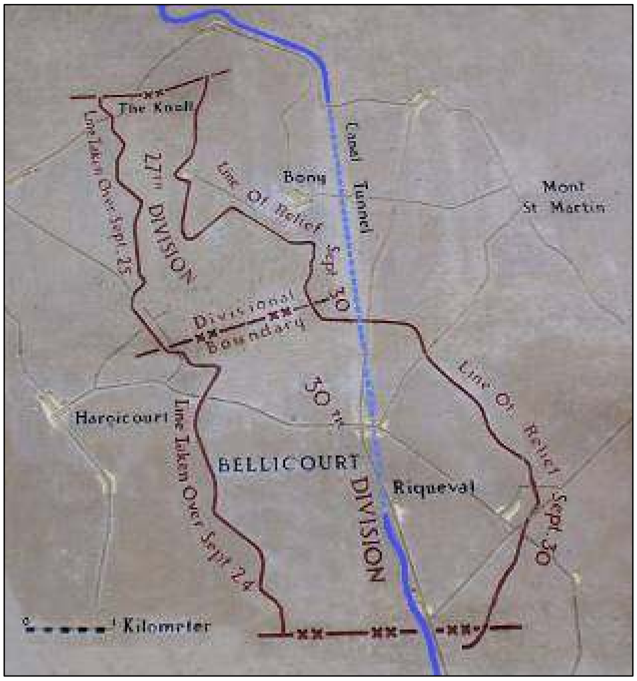
Six-hundred-volt DC chain tugboats, 25 meters bow to stern, 5 meters wide and 1.7 meters high, 90-ton displacement, were introduced in 1906.

During the First World War, the Riqueval "Schiffstunnel" (canal tunnel) served as a German Hindenburg Line bunker fortified at both ends and occupied by 34 barges serving as barracks.

A network of tunnels led to two lines of trenches. The defenses incorporated the steep banks of the canal.



German defenses



By late September of 1918, the British were approaching and the attached US 2nd Corps was assigned the attack.

On September 29, the American captured the tunnel entrance, inside the molehill fortress finding a field kitchen littered with German bodies, one of them in a cooking cauldron. That the enemy was boiling down its dead was exploited by the Allies' propaganda machine, but subsequent investigation proved that an exploding shell in the improvised kitchen killed the unfortunate cooks and threw one into the pot.

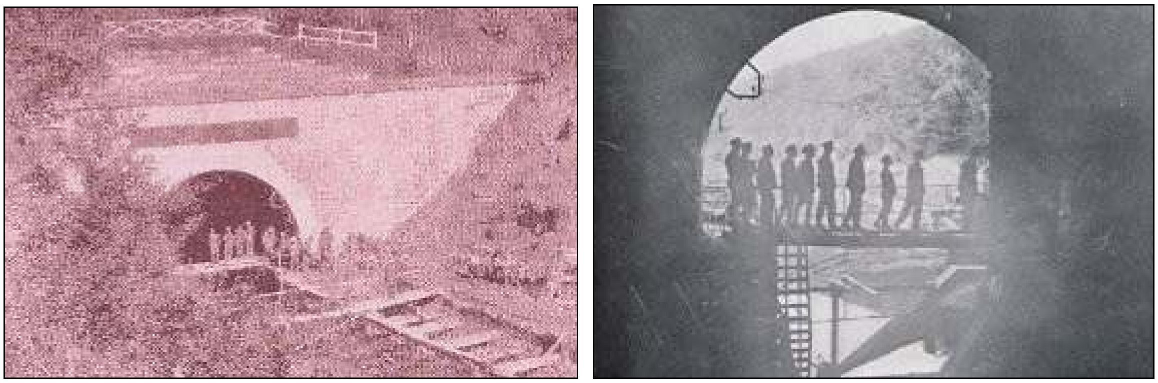
A newspaper account, "Huns Lay in Ambush for the Yanks. Germans Waited in Canal Tunnel for American Onrush. Fight under Mountain Lasted from Yesterday Evening until Early this Morning -- No Huns Left," Lawrence Journal-World, October 1, 1918,

> *The St. Quentin canal tunnel runs for more than five kilometers under the mountain. The canal was held by a large number of Germans who were aboard electrically lighted barges. There are wide towpaths and galleries leading from each side of the canal and in them the entire garrison had quarters.*
>
> *This section probably is one for the strongest parts of the entire Hindenburg system and the Americans have found it to ne literally lined with tunnels, dugouts and galleries which require a great deal of mopping up. Large numbers of Germans have been killed, but they were silenced they worked their machine guns with the greatest vigor.*
>
> *When the Americans swept past the southern end of the tunnel, the Germans remained hiding until the Americans got past and then they surged up and plunged into the fight. They were engaged first by the Americans and then by the Australians. The tunnel mouth was choked with dead.*

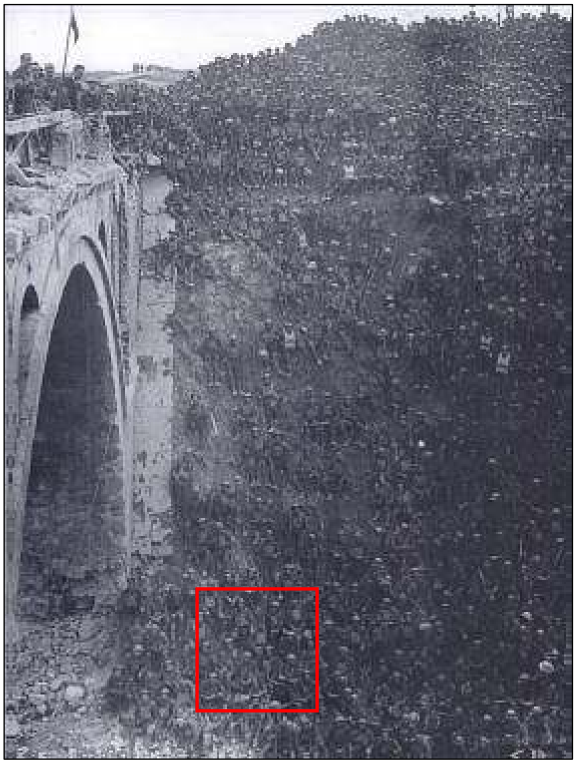
From the official history of the American 30th Division, "Old Hickory,"

> *The large tunnel, through which the canal ran, was of sufficient capacity to shelter a division. This tunnel was electrically lighted and filled with barges. Connecting it with the Hindenburg trench system were numerous tunnels. In one case a direct tunnel ran from the main tunnel to the basement of a large stone building, which the enemy used for headquarters. Other tunnels ran from the main tunnel eastward to the City of Bellicourt and other places. This complete subterranean system with its hidden exits and entrances, unknown to us, formed a most complete and safe subterranean method of communication and reinforcement for the German sector.*

While the canal locks were entirely destroyed and many dikes breached, the vault -- except apparently the kitchen -- was little damaged.

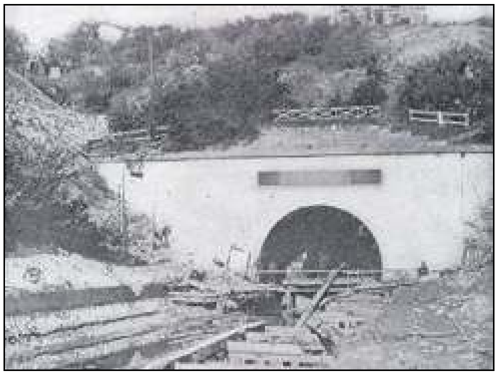


American forces

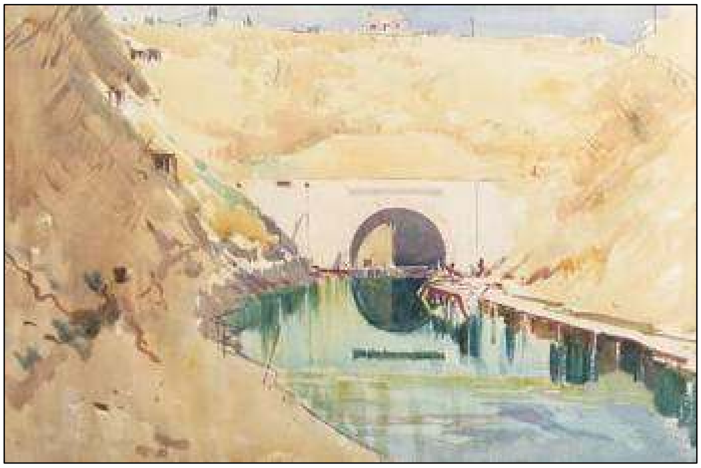


Went up to Bellicourt this afternoon to see the famous canal tunnel. Found the entrance about half a mile from the town. Got a candle and went into the tunnel. It is a dark, evil-smelling place. The canal in the tunnel is full of barges, which have been used as billets by the Huns, but how they could bear to live in such a place I don't know. Went along for about half a mile in the tunnel, but was glad to get out and leave it. -- The World War I Diary of Percy Smythe, Monday, 7, 1918

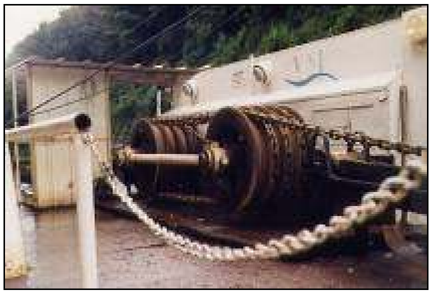
British troops at Riqueval Bridge

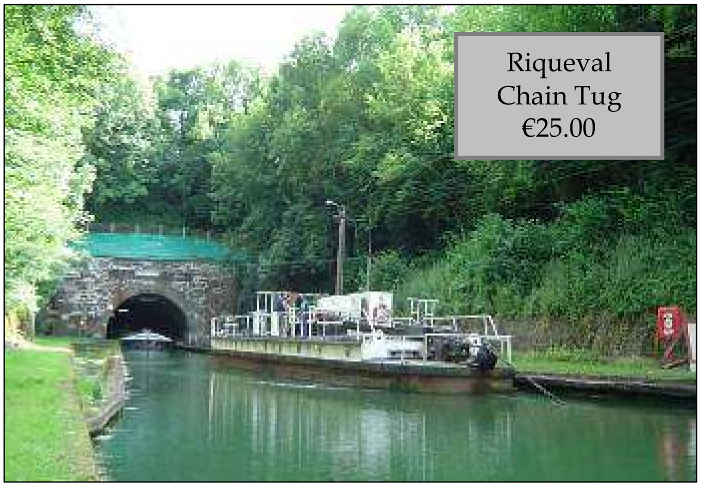


"Bellicourt Entrance, St Quentin Tunnel," 1918 watercolor by Australian painter Arthur Streeton, commissioned to record the involvement of his countrymen in the battles taking place along the Somme River.



A 1924 chain tugboat today hauls mostly pleasure boats. This underground river train ("rame"), averaging 30 craft, departs at 07:10 and 15:10 in the northern direction and at 09:30 and 17:30 to the south.





Riqueval
Chain Tug
€25.00

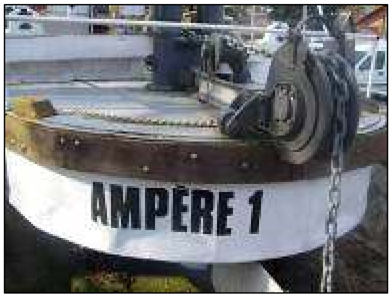
Power is obtained via contact with a copper wheel to venerable overhead lines visible in the photos above. At each point of suspension, a crew member guides the wheel over the high point of the overhead line with copious of sparking. Moving 3 kilometers/hour, the voyage takes 2 hours with each boat's crew vigilant to prevent their hull from scraping the tunnel wall.

"Canal de Saint-Quentin" by Mouringh van der Vinne, a poem in Dutch, loosely translated, catches the spirit of the transit.

De kettingsleper trekt zich voort	*The tug pulls forth*
met veel lawaai en weinig gang	*with great noise and slight progress*
naar 't lichtje dat mijlenver gloort	*towards the light that glimmers miles ahead*
aan 't einde van de duistere gang.	*at the end of the dark corridor.*
De schepen, weerloos aangelijnd,	*The ships, helpless leashed,*
stuiten soms stevig op de wanden.	*scrape against the walls*
De galm van schurend ijzer schrijnt	*The reverberation of abrasive iron hurt the ears*
terwijl de schippers knarsetanden.	*while the skippers gnash their teeth.*
In 't donker flitst de bovenleiding,	*In the dark the flashes overhead,*
hier is het erger dan de hel,	*are worse than in hell,*
maar eindelijk daagt toch de bevrijding	*but freedom dawns at last*
en schijnt de zon ongekend fel.	*and the sun shines brightly.*
Er is weldra weer blauwe lucht,	*There is soon again blue sky,*
een schipper slaakt een diepe zucht.	*a skipper sighs.*

Another vintage chain tug, the Ampère, was retired after 75 years and is displayed at the entrance of Le Musee du Touage. The photo illustrates how the chain is lifted to and dropped from the vessel.

The year 2010 was both the bicentennial of the tunnel and the centennial of its electric chain tugboats.'



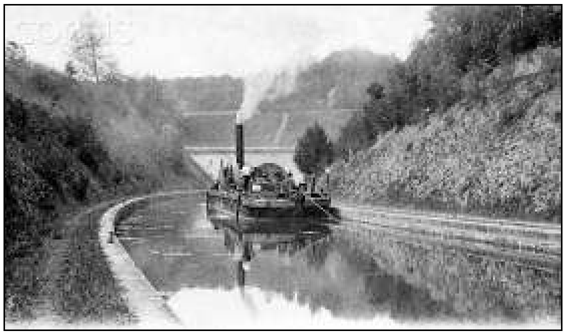
Mauvages Tunnel, Canal de la Marne au Rhin

Length: 4,877 meters. Width: 5.2 meters. Height: 5.7 meters.

France's only other active electric chain tugboat operates in the Mauvages. As the tunnel is not straight, piloting is difficult.

Begun in 1842 and put into operation in 1853, two steam-driven chain tugs moved trains of 17 ships at 1.25 kilometers/hour

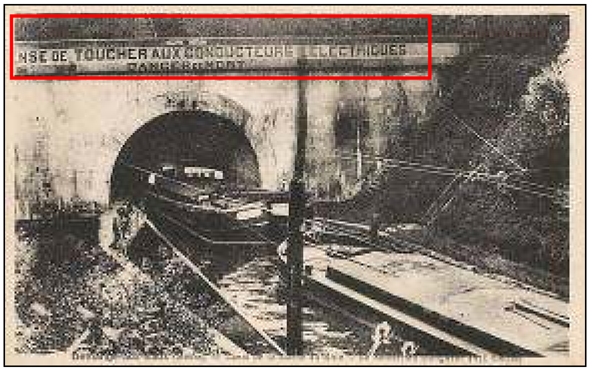
Since 1912, electrically-powered chain tugs have done the hauling, pulling up to four vessels at about 2.5 kilometers/hour. The tugboat of 1933 is still working.



Steam Chain Tugboat, Undated

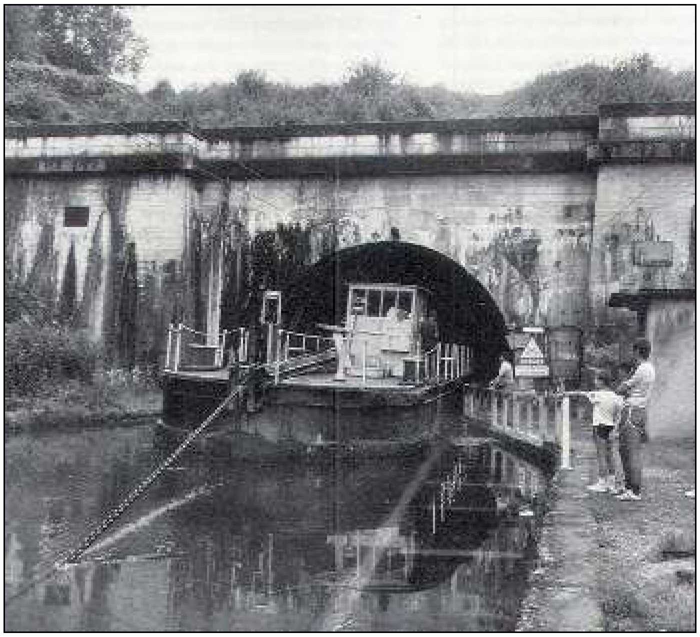
Undated

NSE DE TOUCHER AUX CONDUCTEURS ELECTRIQUES
DANGER DE MORT


NSE DE TOUCHER AUX CONDUCTEURS ELECTRIQUES
DANGER DE MORT

1936

Undated



1912 chain tug still in operation

Today's interior and exterior

"Notice to Shipping" includes the following:

> *Towing with the electric tug is compulsory for all ships in order to avoid emissions in the tunnel. Motors and generators must be turned off. Cooking, baking, heating and open flames are prohibited. Smoking is also prohibited. For security reasons, up to 8 people are allowed per boat. In order not to contact ceiling power lines during the passage, do not leave the interior of the ship. It is prohibited to scream. If you have a problem, make it known by repeatedly honking the tug personnel.*

Balesmes Tunnel, Marne à la Saône

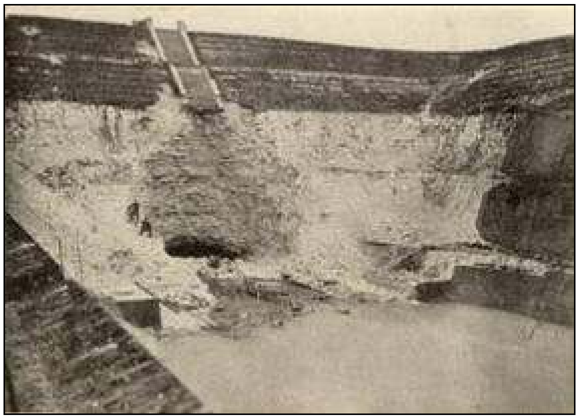
Length: 4,800 meters

Constructed in the 1880s, the Balesmes spans the summit between Balesmes-sur-Marne and Noida -Chatenoy.

A chain tug driven by horses operated until 1946 when it was converted to diesel. Towing was abandoned in the 1960s and today's voyagers sail under their own power.

Ruyalcourt Tunnel, Canal du Nord

Length: 4,354 meters



World War I damage

Today

Painting by Pierre Lemoine

1000-meter passing zone in the center.

Pouilly-en-Auxois Tunnel, Canal de Bourgogne

Length: 3,000 meters. Width: 5.8 meters.

Tunnel construction was completed in 1832. Originally, the sailors manhandled their boats through the passage, the effort requiring 8 hours. In 1867, a steam-powered chain tugboat drew several barges at a time.

Electric chain tugs, 15 meters long, 3.2 meters wide and a 0.5-meters draft, replaced the steamers in 1893. Water released from locks powered a 22 kW turbine.

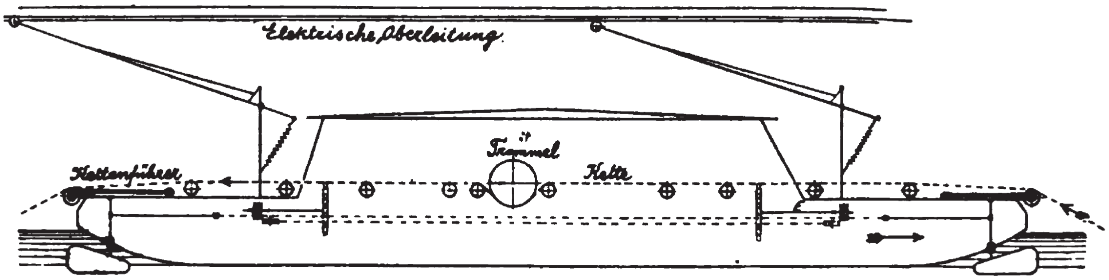
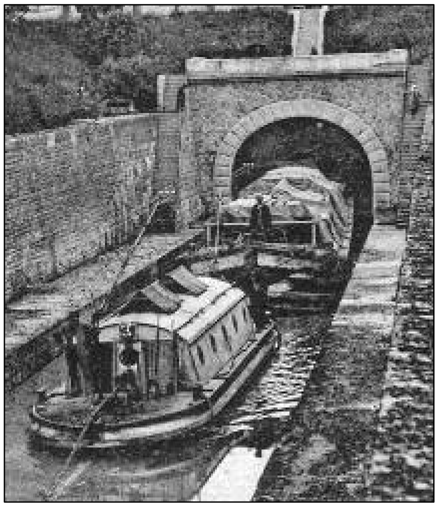


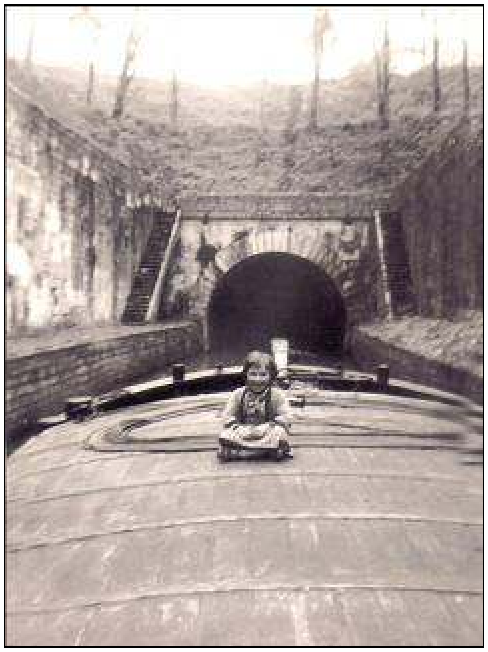
Bild 274. Elektrische Kettenschiffahrt am Bourgogne-Kanal.



Electricity not only propelled the craft, it also lighted the way, as noted by Thomas Martin in Electrical Boats and Navigation (1894)

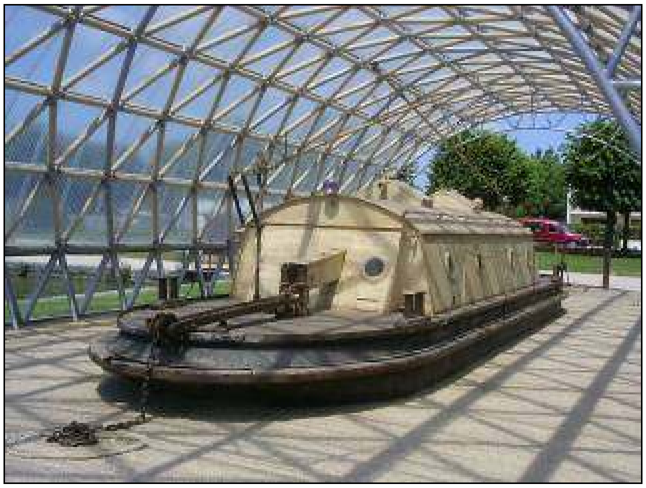
> *The tunnel of 3.3 kilometers mentioned is lighted by incandescent lamps which are branched in multiple on the power circuit. It may be said that this electric canal installation has given such satisfaction that it is certain that before long similar methods will be largely employed in France*

The 1921 photo shows the chain and the metal arm touching the cables above. Boat speed reached 4 kilometers/hour



Left: The boatman's daughter, we'll hypothesize, enjoying the ride, undated.

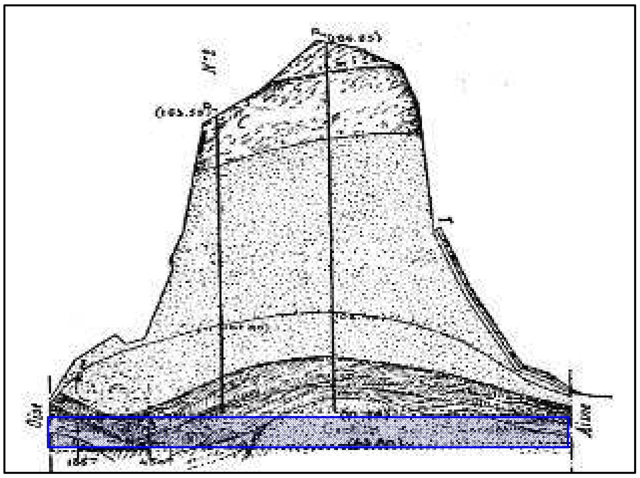
Below: A chain tug on display in a shell that simulates the dimensions of the tunnel.

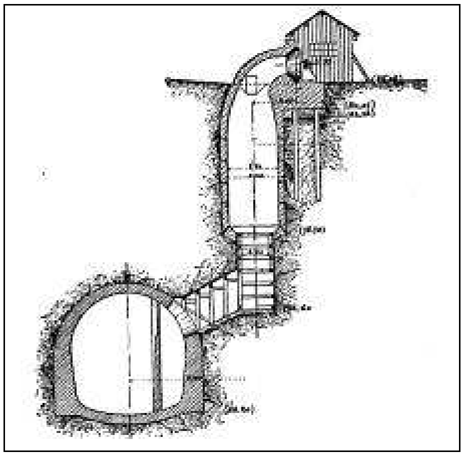


Braye Tunnel, Canal de l'Oise à l'Aisne

Length: 2,365 meters

The Canal de l'Oise à l'Aisne is a summit level canal about 100 kilometers north-east of Paris. To counter infiltration, construction workers had to labor under compressed air conditions. Fires ignited by the elevated oxygen and lignite in the rock killed 17 in 1884.



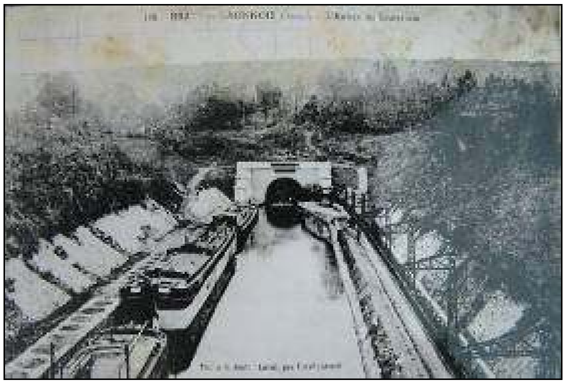


Ventilation works

BRAYE-en-LAONNOIS (Aisne)

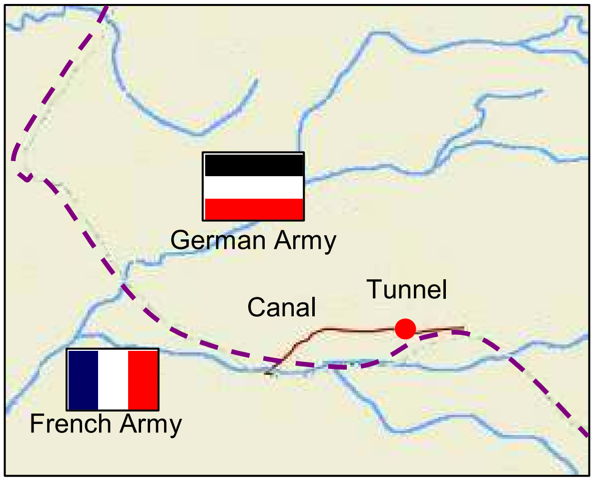
BRAYE-EN-LAONNOIS — Canal de l'Oise à l'Aisne, entrée du Tunnel

BRAYE-en-LAONNOIS (Aisne)
Entrée du Tunnel permettant le passage sous le Chemin des Dames du Canal de l'Oise à l'Aisne
Travail exécuté par l'Entreprise Fougerolles

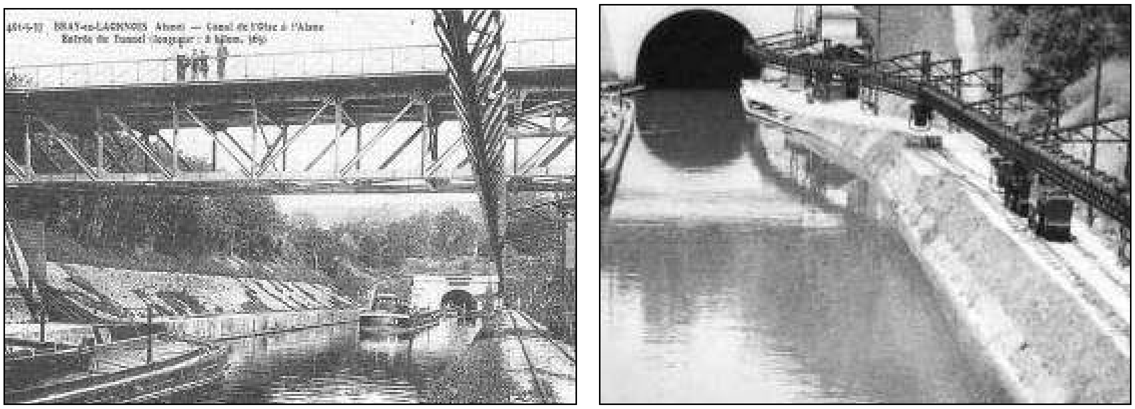


Braye Tunnel lies 110 meters below Chemin des Dames Ridge, the scene of one of the most costly engagements of the Great War. Germans casualties numbered 163,000, French, 271,000.

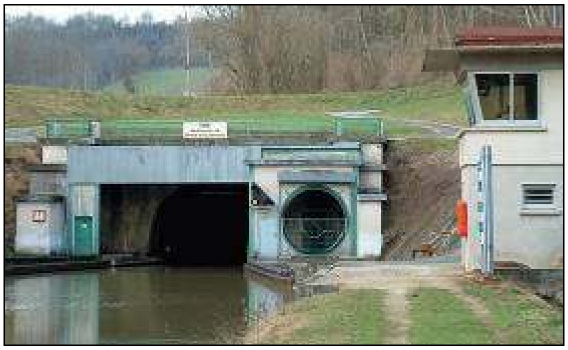
Front line, early 1917


German Army
Tunnel
Canal
French Army

The Braye was not reconstructed until 1931.


BRAY-en-LAONNOIS Aisne — Canal de l'Oise à l'Aisne

Towing traction was provided by a 600-volt tractor riding a monorail, a towing system that remained in operation until the 1960s.



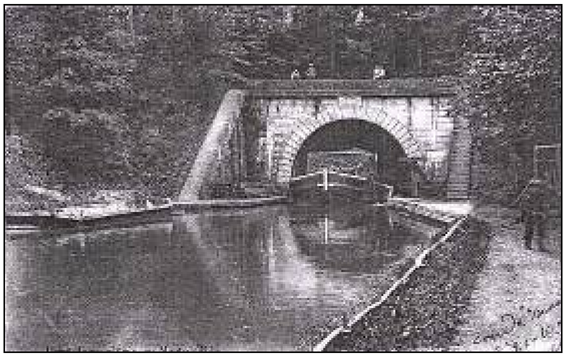
The command post at the southern entrance. An aeration system was added in 1972 when boats were motorized. Traffic is one way, signaled by lights

Ballasted boats waiting their turn at the north entrance. The wait can sometimes take an hour.

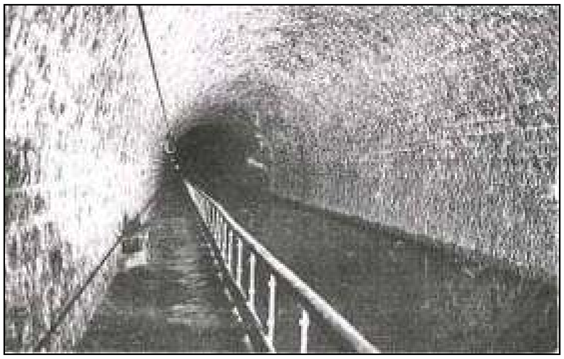
The Braye remains a major bargeway, avoided by pleasure-craft.

Billy le Grand Tunnel, Canal de la Marne au Rhin

Length: 2,330 meters

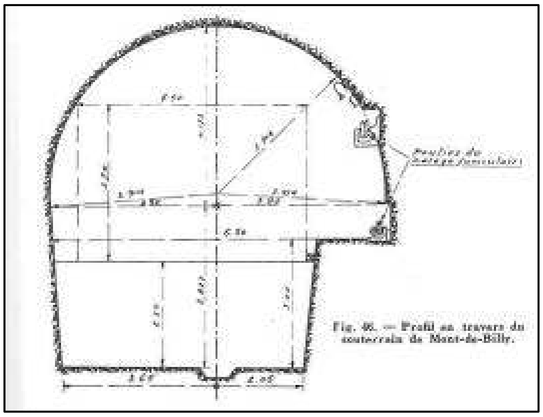


1913



Undated

Above, right and to the right. Billy le Grand was originally equipped with a looped towing cable operated by a fixed outside steam engine. The first boat of the train was attached to the cable by a tether weighted with lead balls. There was telephone communication between the ends of the tunnel.


Poulies du halage funiculaire
Fig. 46. — Profil en travers du souterrain de Mont-de-Billy.

1935 Cross-section

The loop moved at 4 kilometers/hour. Barges could be started or stopped by connecting or disconnecting the cable grip with a device on the boat.

1940, the final year of the tow cable

Today

Electric tugs operated between 1940 and 1974, able to tow a train of seven at 4 kilometers/hour. In 1955 the large pulley at the entrance had been removed to allow passage of tugs, but the other pulleys were still visible. Boats today rely on their own power.

Arzviller Tunnel, Canal de la Marne au Rhin

Length: 2,306 meters

Arzviller was drilled between 1839 and 1849. Barges were originally pulled along the towpath by horses, and later, by small steam engines. It is now forbidden to cross the tunnel by foot for safety reasons.

British Troops exiting the Arzviller, 1919

Tronquoy Tunnel, Canal de Saint Quentin

Length: 1,097 meters. Width: 5.2 meters

As the Riqueval is the "Grand Souterrain," the Tronquoy Tunnel on the same canal is "Le Petit Souterrain."

Before the chamber was flooded, Napoleon himself came to inspect the works on horseback, preceded by an honor guard and followed by a platoon of lancers. As a result of a misunderstanding, however, the lighting wan not completed and, the emperor found himself in the dark. When his mount stumbled on a ladder forgotten by the miners, Napoleon immediately surmised an attack and cried, "À moi ma garde," "I'll keep to myself," spurring his horse through his horrified protectors.

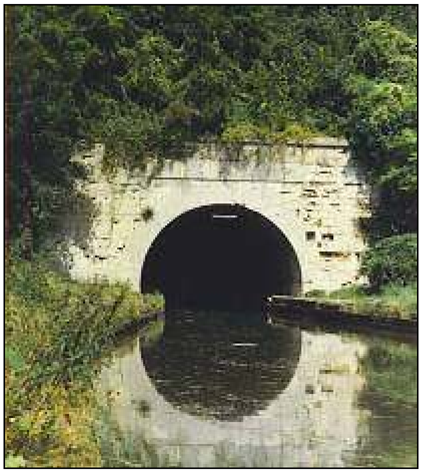
William Moens, whom we quoted regarding the Riqueval, likewise commented on the Tronquoy.

> *We reached the first tunnel, that of the Tronquoy at 4:26; the route was clear and it was not very long, only about three-quarters of a mile; so without any hesitation we entered it, the height of the vault being about seventeen feet, thus giving two feet clear above our funnel. It is not a pleasant thing imagining that some stone or other may fall on your head, and though the light was visible as a speck at the other end, it was as dark as possible after we had entered a few yards. The large masthead light was placed in the extreme bows of the vessel, and a hand on each bow held a light directed against the walls; but when a tunnel is quite straight, and it is possible to see the light of day at the exit, the best guide is to get the edge of the funnel in one position against the light, and keeping it there steadily, the vessel goes straight as an arrow.*

> *Guiding her this way, we emerged into the light of day in eleven minutes, without once touching the sides, though there was not much room to spare, the width of the water channel being only seventeen feet.*
>
> *When we had steamed a short way on the other side of Tronquoy Tunnel, to our horror, we saw at least a kilometer, or five-eights of a mile, of barges connected together, and all towed by means of the submerged chain, one small tug doing all the work. It was impossible to pass them with safety, so we hooked on behind them and entered into a conversation with the owner of the hindmost vessel. He told us that they had been one hour and a half in passing through the tunnel, in which we had been only eleven minutes.*

LESDINS (Aisne) — Canal de Saint-Quentin - Arrivée d'une rame de bateaux

Electric chain tug waiting at the entrance, early 20th century

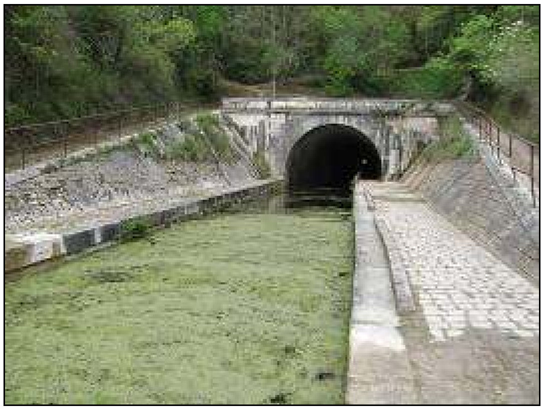


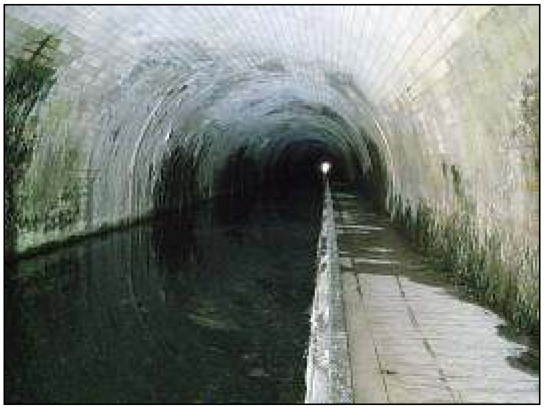
Today

Saint Léonard Tunnel, Canal Marans LaRochelle

Length: 1,830 meters. Width: 8 meters

Construction stretched through much of the 1800s with the forced labor of prisoners. It is not navigable today.



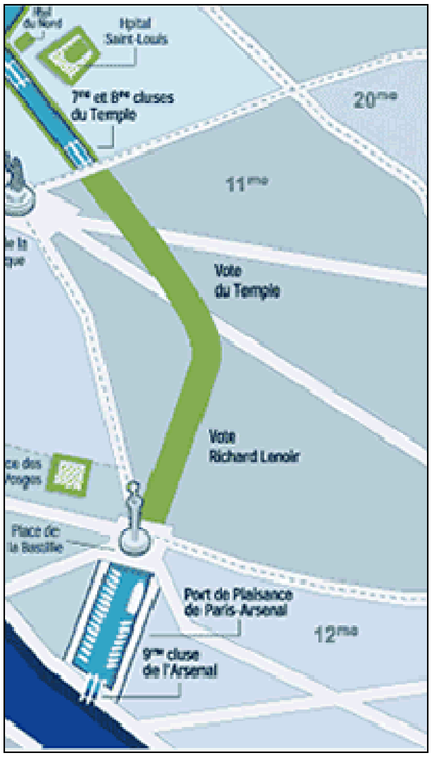


Canal Saint-Martin, Paris

Length: 1,830 meters. Width: 7.8 meters

The Canal Saint Martin anal was constructed from 1802 to 1825 to provide an additional freshwater source for a burgeoning Paris. The works were funded by a sur-tax on wine. Unlike the other canals in this chapter, this waterway was fully constructed in open air and the enclosure was came later

The canal's lowest lock was moved upstream from the river bank in 1862 and the lower reach of was vaulted between Place de la Bastille and Avenue de la Republique to improve the docking, creating Boulevard Richard-Lenoir. The enclosure was further extended to Rue du Faubourg du Temple, creating Boulevard Jules-Ferry in 1906.


Hpital Saint-Louis
7^{me} et 8^{me} cluses du Temple
20^{me}
11^{me}
Vote du Temple
Vote Richard Lenoir
Place de la Bastille
Port de Plaisance de Paris-Arsenal
12^{me}
9^{me} cluse de l'Arsenal

Underground section in green

509. - PARIS. - Aqueduc du Métropolitain et Canal St-Martin à la Villette

Turn of century

1970s

Locks

The tunnel uses sunlight from portals above.

1890 and today

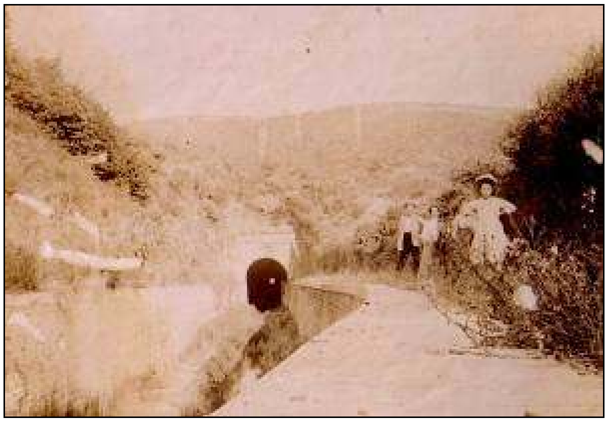
Today's visitors can explore the canal by boarding tour boat at the yacht harbor Port de l'Arsenal, delving into the darkness beneath the Bastille and floating beneath the remains of some 500 victims of the 1830 revolution. After the canal exits to open air, the tour becomes more Parisian.

Canal Saint Martin
€16.00

Chérimont Tunnel, Canal de la Haute-Saône

Length: 1,330 meters

Constructed in the latter 19th century to compensate for the loss of infrastructure to the Germans, the Chérimont was intended for coal haulage.



Family outing, 1911

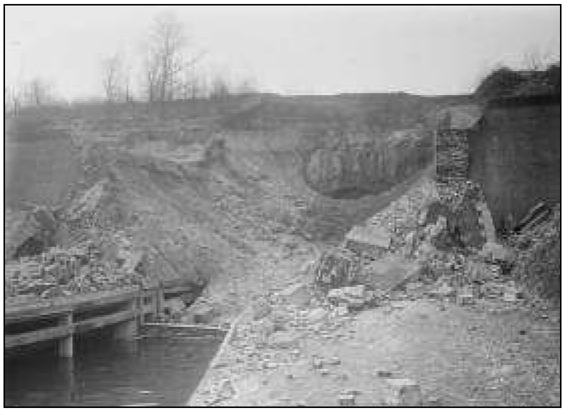
Undated

Today the canal's a route for pleasure boats.

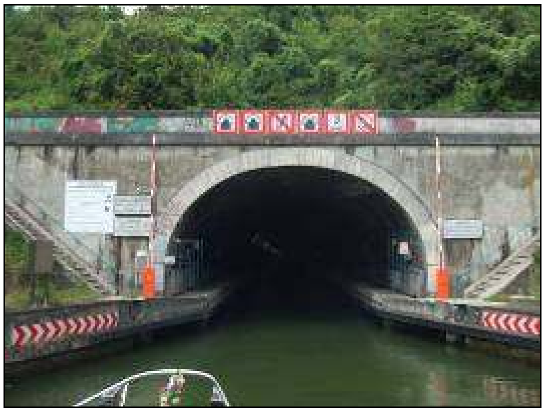
Panneterie Tunnel, Canal du Nord

Length: 1,061 meters, Width: 6.1 meters

The entrances were mined during World War I, but the refurbishment wasn't completed until in 1965. The tunnel is one-way.



World War I



Today

Foug Tunnel, Canal de la Marne du Rhin

Length: 866 meters

Foug illustré

La Lorraine Illustrée
Environs de Toul. — Foug. - Tunnel du Canal

1909

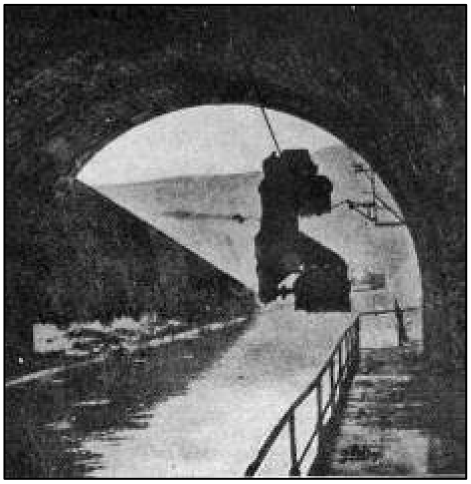
Since its construction in 1845, barges have been towed through the tunnel first by mules, then horses, then with an electric winch and then until 1980, by electric trolleys

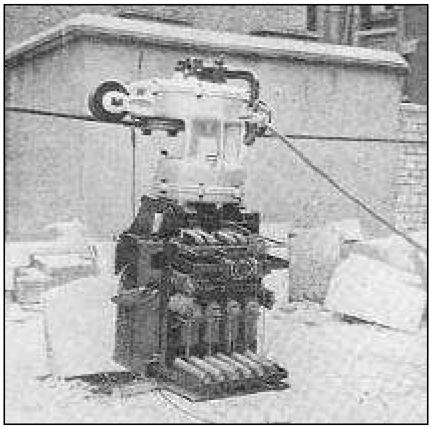
Today, barges motor through under their own power.

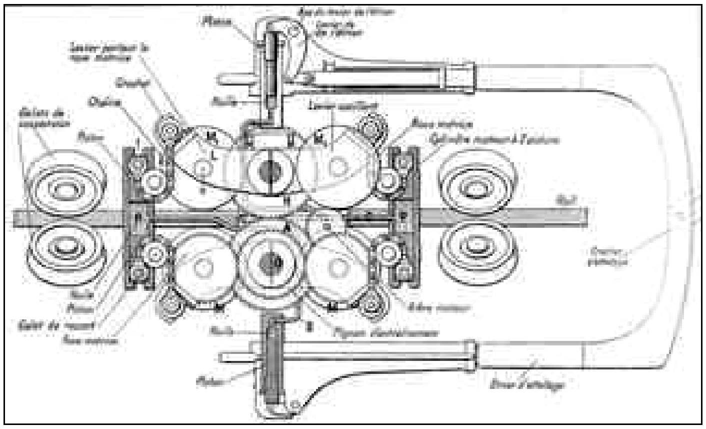
Liverdun Tunnel, Marne-au- Rhine

Length: 388 meters

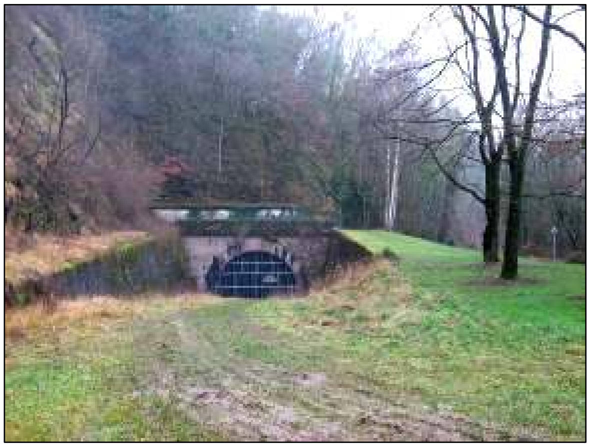
Liverdun is noteworthy for two reasons, the first being that in 1924 it hosted the prototype "zinzin," a 600-kilogram locomotive suspended on a fixed cable. A trolley-line parallel to the cable powered the motor.





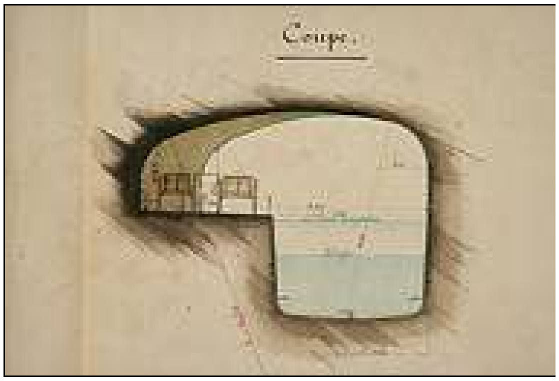

Piston
Levier portant la roue motrice
Crochet
Chaîne
Galets de compensation
Piston
Bielle
Levier oscillant
Roue motrice
Rail
Arbre moteur
Bielle
Piston
Bras d'attelage

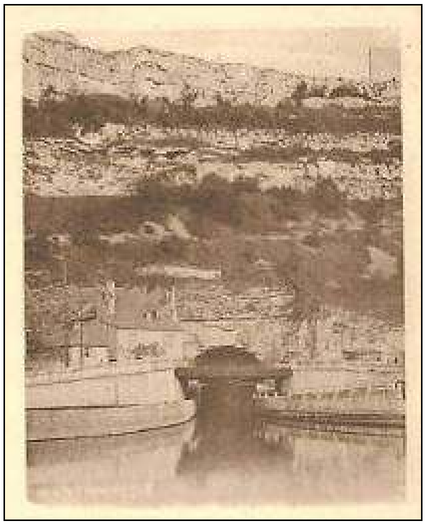
Liverdun's other distinction is that the canal was refilled in 1978.

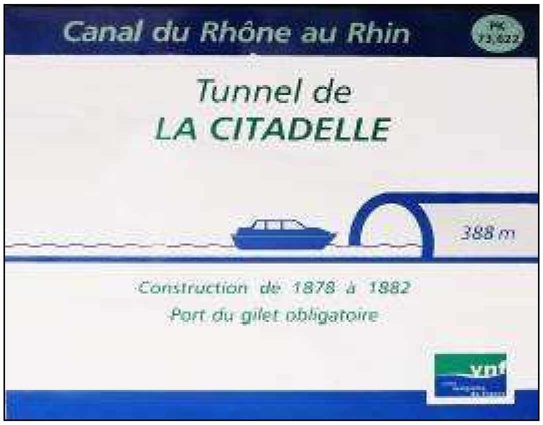


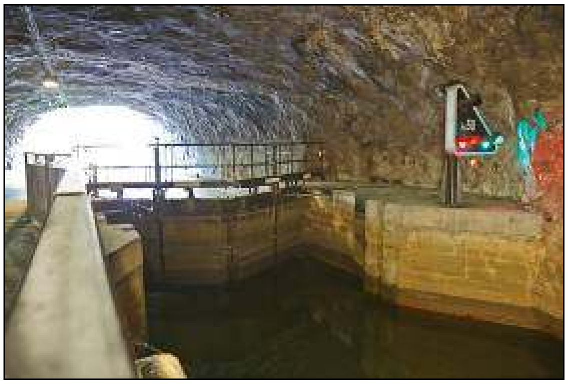
Besancon Citadelle Tunnel, Canal du Rhône au Rhin

Length: 388 meters






Canal du Rhône au Rhin
Tunnel de
LA CITADELLE
388 m
Construction de 1878 à 1882
Port du gilet obligatoire
vnf

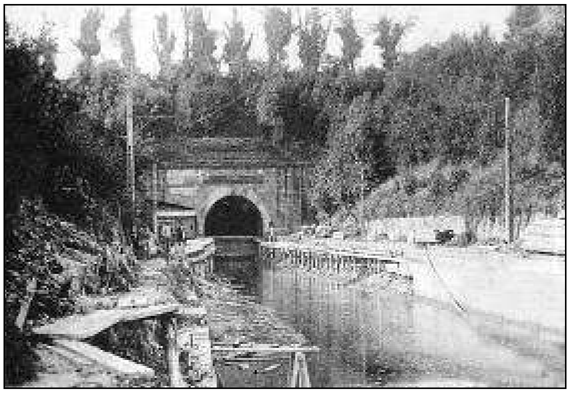


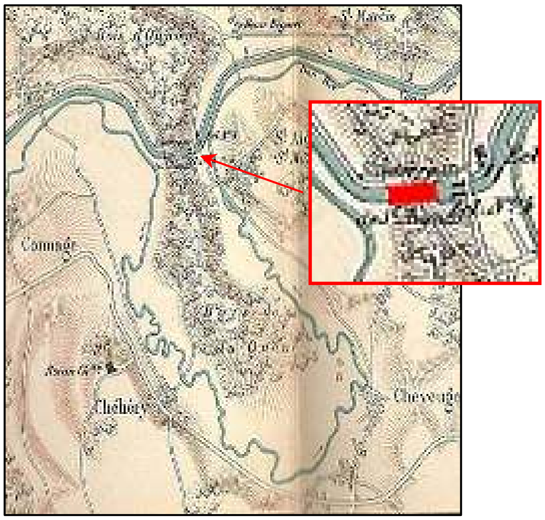
Interior lock

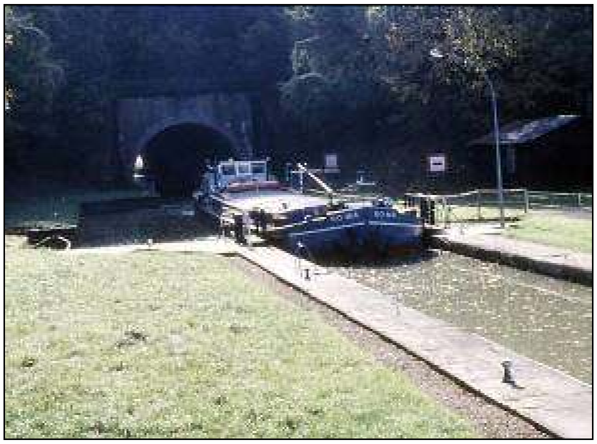
Saint Aignan Tunnel, Canal des Ardennes

Length: 195 meters

The transport distance saved by the short Saint Aignan is apparent from the 1885 map.




Connage
Chéhéry
Chevenge



Barge traffic

Bike traffic

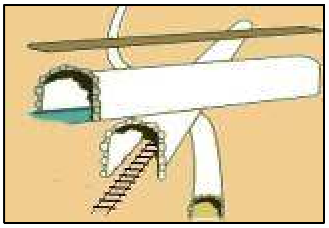
Malpas Tunnel, Canal du Midi

Length: 173 meters. Height: 8.4 meters.
Width: 6.8 meters

The Malpas, excavated in 1679, was Europe's first navigable canal tunnel.

The Chevalier de Clerville, architect to Louis XIV, advised to cross the River Aude rather than tunnel through the hill, but chief engineer Pierre-Paul Riquet maintained his preference for a subterranean route.

By the time the Malpas was excavated, the hill had already for centuries been the site of a tunnel to drain the Étang de Montady. A third tunnel, between the two, was excavated in the 19th century as part of the Béziers to Narbonne railway line.



Voyage de Fin

We've boated a beaucoup of French canal tunnels, a few still commercial arteries, but most now holiday routes.

We've increased our French vocabulary.

"Toueur," a tugboat,
"Rame," a train of barges,
"Touage," towage, of course, and
"Flottage," a floatage, if that's an English word.

As well as our German.

"Schiffstunnel," canal tunnel.

But now we must bid au revoir to these particular subterranean waterways and venture where the danger is more than that of spilling our glass of vintage wine in the darkness.

CHAPTER 68
MORE PERILS

We're on no nancy-pancy journey. Perils lurk at every dark riverbend. In Chapter 40 we saw dire consequences of sinknoles. We dealt with the dangers of cave diving in Chapter 64 and underground boating in Chapters 49 and 63. Chapter 66 dealt with mining. In this chapter we will mention a few more risks associated with underground rivers.

Swimming in Potholes

Hawaii's legendary goddess of fire, Pele, guards the lava-tube entrances to her molten domain. The Wailuku River on the Big Island is famed for its Rainbow Falls. Above the falls are the aptly-named Boiling Pots where the river churns through a succession of Jacuzzi-like "pots" where flow dives beneath a stratum of old lava.

Question and Answer from hilo-hawaii.com concerning 'au'au (bathing),

> Q: *My guidebook says we can swim at Boiling Pots.*
>
> A: *Absolutely do Not!..And don't climb down below the viewing area. Besides the chances of leptospirosis, the Boiling Pots area is laced with lava tubes, some horizontal, some vertical like hourglasses. The water appears to boil as it goes into, then shoots back out of these tubes. Most are underwater, out of sight, and it is too easy to be sucked into these tubes, even when the water appears low. There is no way out alive. It has happened for so long. Hawaiians had legends about a great mo'o, or lizard, that lived in the river. Occasionally it would pull someone under, and release the body several days later. "Wailuku" means "river of destruction." It is an "ai kanaka." It "eats men."*

Wading

The rule of thumb is that it's dangerous to wade if the product of depth in meters and velocity in meters/second exceeds 1. And that assumes that we can see where we're stepping.

For an underground water wading reference, we have "Underground Current" from Imperial Valley Press, August 23, 1902

> *William Moore has just completed a new well near his ranch near Coldwater, from which he pumps water to irrigate his ranch. The well is only sixteen feet deep with a stream of water three feet deep running through the bottom. Mr. Moor says, "I can hardly stand up in the well, the current is so swift... It seems to be an underground river."*
>
> *Mr. Moore raises some very large watermelons, and yesterday cut one that weighed sixty pounds. He is expected to arrive in Phoenix today with one that will weigh eighty pounds. This sounds pretty big, but it is a fact.*

The melon indeed sounds big and the farmer, foolish.

Falling In

"A Wonderful Escape," The Youth's Companion, October 27, 1898, provides an account from northern Florida.

> *Recently a party of twelve negroes were fishing in the creek, when two of them, losing their balance on the slippery bank, fell into the water and were whirled into the underground stream by the swift current.*
>
> *Their horrified companions tried to rescue them, but in vain, for almost instantly they were swept out of sight. The party rushed to the lower end of the land, where the creek reappears.*
>
> *Scarcely had they reached the place when both negroes shot into sight. They were still alive, and were seen to be feebly struggling in the rapid stream.*
>
> *A dozen men plunged into the water and brought them to shore, where, after much rubbing and work on the part of their friends, they were restored to full consciousness. They could tell nothing of their perilous experience, except that it was very dark and the current was swift.*

The same incident was reported in the San Francisco Call of June 11, 1895, as "Two Negroes Swept Through an Underground River and Escape Death. They were Fishing and Falling Into the River Were Carried Half a Mile."

> *Nathan Brooks and Joseph Gillen fell into the water and were almost instantly whirled into the underground creek by the swift current... They were swept away uttering loud screams of horror and terror.*
>
> *The party hastily rushed to the lower end of the land where the creek reappears. Shortly afterwards both men shot through, feebly struggling in the swift current and showing slight signs of life. Several men plunged in and brought them to shore, and they were worked over for half an hour before they were out of danger.*

Quincy Daily Whig, September 17, 1890, offers an account of a plume-hunter's misadventure.

> *Presently I saw a good sized stream glimmering through the trees, the silver river seemed to end abruptly, and it looked very puzzling until I reached the bank, when I saw that I had run across one of Florida's natural wonders, of which I had often read.*
>
> *But I was after the water, which was clear and cold. So I stepped down the bank quite a distance above the cataract and tried to unscrew the cover of my tank. The obstreperous piece of metal was stuck tight, and while I was wrestling with it, the crumbly clay bank gave way and I slipped into the water, still clinging to my water tank, which buoyed me up as a life preserver. I clung to it and kicked for the shore.*
>
> *I had about a hundred feet to drift, and although I could touch the bank at time, I could find nothing to grasp but the treacherous crumbling clay. Buoyed up by life preserver, I swung round in a swirling eddy, and with one last cry for help and a kind of dreamy wonder as to how far down I would drop, my breath left me. After the first antagonizing plunge down -- it seemed to me hundreds of feet -- my head shot out into the air for a moment, and I saw that the stream was running horizontally through a black, rayless cavern on whose walls the spray was splashing...*
>
> *When my senses returned, I was floating quietly on the surface of a body of water, my arms still held by the strap of my life preserver, which had indeed saved me... I paddled slowly to the nearest shore and fell down in the grass, bruised and wearied. In the moonlight I saw that the pool I had just left was circular and about a hundred yards in diameter, black and deep, but without a ripple.*

From Farmers' Review, March 8, 1898,

> *A queer accident happened to Michael Magona, at Rutherford, Tenn., last week. He was digging a well to supply the cattle with water during the summer. At the depth of sixty feet the bottom fell out of the well and Magona plunged headlong into an underground river and was*

> *drowned. The rushing waters below acted like a suction, and the windless and dangling apparatus were drawn in. Magona's associates, panic-stricken with fear, gave the alarm, and the whole neighborhood turned out, but no trace of the unfortunate man could be found until after several days, when is body was discovered floating in the Obion River, four miles below.*

Traversing above Subterranean Waterbodies

Staying dry while crossing an underground lake can be difficult. There are three ways to do so.

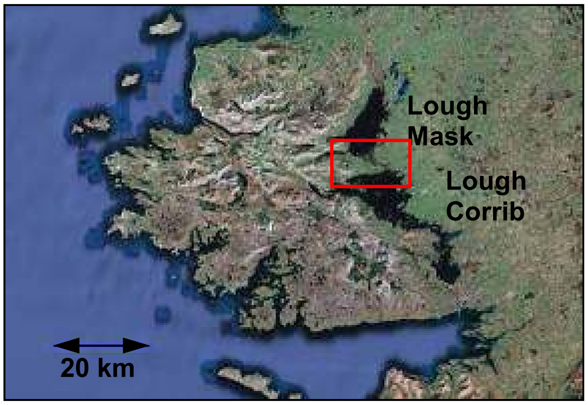
> Swimming. Chapter 64 describes the danger.
>
> Boating. Chapter 65 gives evidence to the risk.
>
> Eco-hangers. The climber traversing the 30-meter Midroi lake, waters we boated in the "Microbe," Chapter 26, illustrates the feat.

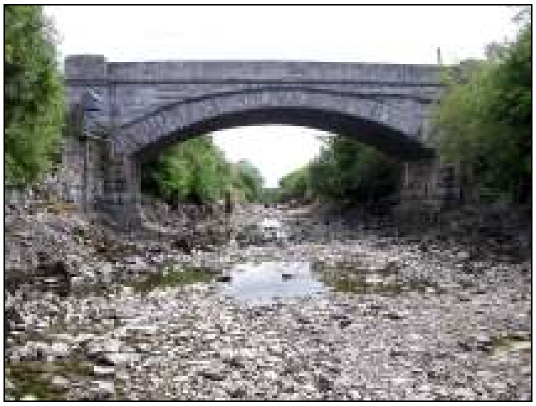
Lost Canals

The Letters of 'Norah' on Her Tour through Ireland (1882) by Margaret Moran Dixon McDougall was a best-selling travelogue of the day.

> *It was determined to make a canal to connect Lough Corrib and Lough Mask. The canal was made at the expense of much blasting, much building of strong and costly stone work. If they could only have resurrected the famous Irish architect Gobhan Saer, he would have advised making a well-cemented bottom for the canal considering that a subterraneous river runs from one lake to the other under it. They did not do this, however, and when the grand canal was finished and the water let on the bottom fell out in places and the waters fell through to their kindred waters. The next famine they will require to dig and blast downward and still downward till they find the underground river and the runaway water.*

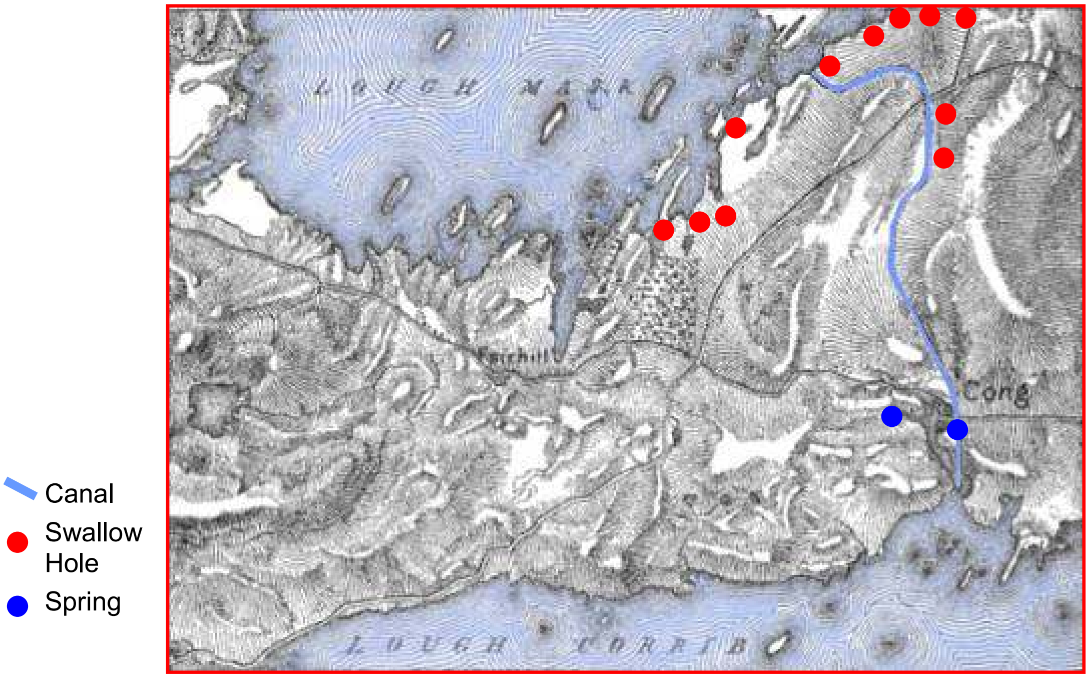
As the geology is karst limestone, the architect's advice was well founded, as evidenced by the photo of the completed project.





Hydrologic detail of the red rectangle is shown in the next figure.

The map below is from "The Underground Emissary of Lough Mask" from The Earth and its Inhabitants with hydrogeologic features overlaid.



From The Earth and its Inhabitants (1876) by Elisee Reclus,

> *The great Lough Mask, which fills a rock basin in Connemara, has no outlet, except through an artificial canal connecting it with the still larger Lough Corrib. But on closer examination it has been found that it is drained by an underground river, which reappears in copious springs at Cong.*

The subterrain between the lakes has been described as resembling Gruyere cheese.

Lost Rivers

There are any number of "Lost Rivers" (Chapter 20), but none as consequential as the feared loss of the Danube. "The Theft of a Great River," Literary Digest, November 10, 1900, warns of the danger.

> *Geologists have long known that one stream may appropriate the waters of another by gradually encroaching upon its watershed and diverting its tributaries one by one. This kind of theft is at least frank and open. It takes place on the surface and every one -- at least every geologist -- can see what is going on. The river Danube, according to expert authority, is suffering from a more insidious form of robbery, by which the Rhine profits, part of the Danube's water being drawn off underground into the Rhine valley. And this may be of great importance to future dwellers by the Danube, for if it is not stopped it may end by causing the river below the point of absorption to become permanently dry.*
>
> *Now it is remarked by Professor Penck that, unless this loss of Danube water is stopped in some way, it will go on increasing gradually until it will take the whole of the river's supply, leaving the lower river-bed quite dry, as it is left occasionally now, according to Quenstedt, in years of drought. Then the gradual deepening of the Danube valley will end at the point of absorption. Below Mohringen will extend a dry valley, while above a "blind valley" will be drained by a subterranean river. This is not a flight of the imagination, for the same thing has happened to the river Foiba in Istria and the Reka near Trieste. The author adds that these and other cases, notably in Dalmatia, show what threatens the Danube valley unless man intervenes. The length of time that elapses before the reappearance of the water at Aach (sixty*

hours) shows that it must make a long circuit, or that it encounters great obstacles underground.

Dynamite was used to access the Riverbed Room, a 90 by 10-meter riverine chamber of Wisconsin's Eagle Cave. Unfortunately, the blast also drained the cave river.

Lost Lakes

In Chapter 66, we lamented the sudden loss of Louisiana's Lake Peigneur to a mining misfortune, but let us also note that nature itself -- and perhaps the CIA -- can be equally disruptive.

Native Americans believed that Medicine Lake, Jasper National Park, Alberta, vanished each autumn due to "big medicine." The "medicine" is a sinkhole in the lake's karst floor.

Medicine Lake fills when the rate of snowmelt exceeds the lake's subsurface capacity to drain, 24 cubic meters/second. The lake is full by late spring and in September, when inflow diminishes, the stage rapidly falls. The karst channel resurfaces 17 kilometers downstream, forming Canada's longest underground river.

In pre-park times, attempts were made to plug the lake's drain, once using old mattresses, another time using two truckloads of Saturday Evening Posts. Parks Canada/Parcs Canada wont, however, allow further efforts.

We can't be sure that it's the same lake, but Appleton's' Annual Cyclopaedia and Register of Important Events (1887) provides a similar story.

> *Abbe Petitot, a Canadian missionary, who has traversed the vast and little explored territory between Great Slave Lake and the Arctic Sea in every direction, found that several of the lakes and chains of lakes were drying up. The deep granite basin of one of the lakes he found completely bare, and in it he saw a yawning chasm shaped like a funnel, through which the waters had been drawn into some subterranean channel. The Indians believe that there are several of these underground rivers in this region.*

And from Pravda, May 20, 2005

> *The landscape on the forest edge near the village looks like the water has gone under the ground from an unplugged gigantic bathtub.*
>
> *A large lake disappeared in Russia's Nizhni Novgorod region overnight. Residents of the village of Bolotnikovo discovered a huge trench instead of a million cubic meters of water on Thursday morning. No other lake appeared in the area.*
>
> *Dmitry Zaitsev, the chief of the local firefighting brigade, said that a large number of trees had been sucked under the ground. "If a human being finds himself in the middle of such a disaster, there will be no chances for a person to survive," Zaitsev said.*

> *Local residents were shocked to find out that their lake had literally vanished from the area. Village fishermen came to the lake early in the morning. "I was amazed to see that there was no water there. All I could think of was -- oh, my God," a local resident said. One of the men assumed that the USA had been involved in such an amazing natural phenomenon: "I think that America got us here," a man said.*
>
> *An official from a neighboring village, Alexander Kluyev, believes that the lake has flown into an underground river. "I think that the vault of a large underground cave came down and connected with a river there. We believe that there is a certain underground river flowing here in the area, and the water of the lake has gone under the ground," said he.*

The accusation against the United States was not substantiated.

The same story reported by UPI as "Russian Lake Disappears Overnight" suggests a linkage to pre-revolutionary leadership.

> *"It looks like somebody has pulled the plug out of a gigantic bath," an NTV correspondent said about the vanished lake.*
>
> *Village youngsters said the lake had been shrouded in "dark mystery" ever since it appeared during the reign of Ivan the Terrible.*

Lost Sustenance

For the worst-case lost-waterbody scenario, we turn to Edouard Martel, whom we met in Chapter 49, Subterranean Watercraft.

"Must Humanity Perish of Thirst? The Possible Desiccation of the Earth through the Depredations of Underground Watercourses," Scientific American, October 1921, summarizes the subterranean explorer's grave concern.

> *Much interest has been felt by men of science of late years with respect to what many of them believe to be the inevitable though, of course, very gradual desiccation of the earth which, of course, implies the eventual destruction of all life as we know it, since vital functions are impossible without moisture.*
>
> *But most of all it is the recent researches in the interior of the ground itself which have "transformed from a hypothesis to a certainty the idea that the waters are gradually making their escape into the sub-soil or calcareous regions, and that there is a substitution among these lithological formations of a modern subterranean circulation for an ancient surface circulation.*

> *M. Martel enumerates and describes a great many very curious examples of the disappearance of springs, the deepening of subterranean rivers, the going dry of wells, etc., which make the future desiccation of our globe seem inevitable.*
>
> *One of the most convincing of the arguments offered to this effect is the perforation of the bottom of the upper galleries in caverns where subterranean rivers have dried up in the course of ages through an actual drawing off of their waters into profounder depths.*

SUBTERRANEAN RIVER ENTRANCE IN THE ROCKY MOUNTAINS

In short, because water will flow downward, those of us dwelling on the topside will be first to be denied.

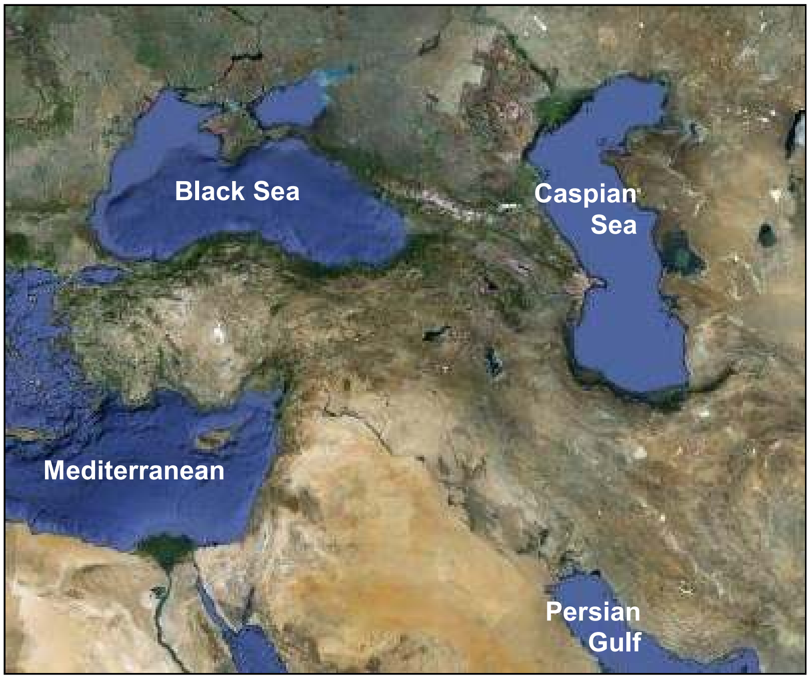
Given so many perils, there are certain to be occasional causalities. Fortunately for the departed, our ancient boatman's still on the job, digitally, at lest.

> *Axiom's Charon Cemetery Management Suite (CMS) offers unprecedented integration and ease of use that is unmatched in the death-care industry.*
>
> *For the first time in the industry, Charon CMS provides a one-stop cemetery management system. All aspects of the Charon system are integrated to operate cohesively and to maximize efficiency in the day-to-day operation of your cemetery.*

eSearch
Electronic Memorials
GIS Mapping
Records
Bookings
Accounting
Touch Screens

CHAPTER 69

THE CASPIAN CONNECTION



The Caspian Sea became landlocked about 5.5 million years ago as a result of tectonic uplift and sea level decline. Today it is the globe's largest inland water body, containing more than 40 percent of the earth's lacustrine waters. The Volga contributes 78 percent of the inflow. The Caspian's salinity is 1.2 percent, about a third that of seawater

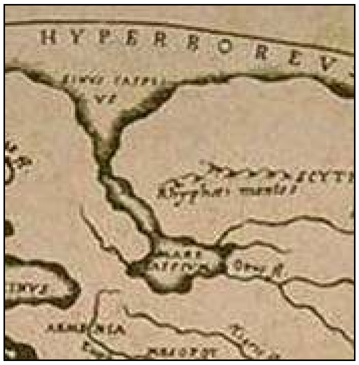
Caspian Water Balance, 1900-1985
cubic kilometers/year

River Inflow	+ 298	(3.8 times the sea's volume)
Direct Precipitation	+ 74	
Evaporation	- 370	(roughly 1 meter/year)
Outflow	- 14	
Total	- 12	

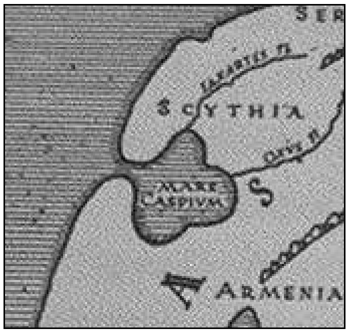
The only outflow is to the adjacent Kara-Bogaz-Gol lagoon from where it evaporates. A dam constructed in 1980 to block this loss was dismantled in 1992. From the sixth century BC to the present, the Caspian's water surface has varied from 20 to 34 meters below sea level.

The Lore

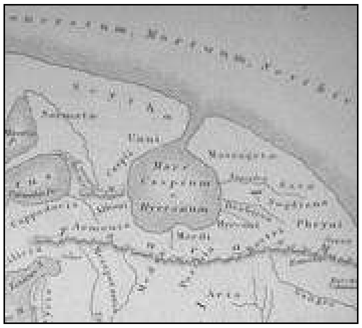
The ancients' perception of the Caspian as a gulf of the Northern Ocean can be seen in various maps.



Posidonius' World Map
(150-130 BC)



Marcus Vipsanius Agrippa's
reconstructed Orbis Terrarum
(20 AD)



Dionysius Periegetes'
reconstructed World Map
(124 AD)

Not until the second century did Ptolemy establish the fact known to Herodotus and perhaps to Aristotle that the Caspian is landlocked on all sides, engendering presumption of a subterranean outlet. Such outflow, we must agree, is a logical explanation for a sea that has no visible way to expel its excess.

In the words of Elisee Reclus in The Earth: A Descriptive History of the Phenomena of the Life of the Globe (1871),

> *In the view of the natives, this inland sea could be nothing but an abyss, a "black gulf," as is expressed by the name Karaboghaz, into which the waters of the Caspian dive down in order to flow through subterranean channels into the Persian Gulf or the Black Sea. It is, perhaps, to some vague rumors as to the existence of the Karaboghaz that we must attribute the statements of Aristotle about the strange gulfs in the Euxine, in which the waters of the Hyrcanian Sea bubble up after having flowed hundreds of miles through the realms of Pluto.*

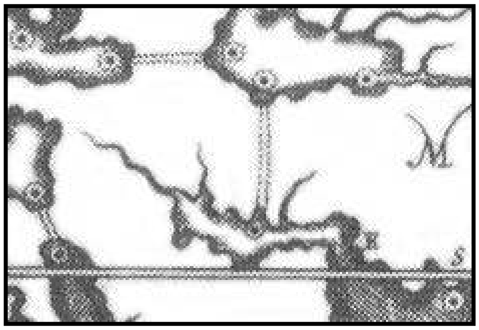
Islamic scholarship (Chapter 5, The Crescent) wasn't immune from perpetuating geographic errors, an example being Monument of Places and History of God's Bondsmen by Persian geographer ibn Muhammad al-Qazwini (1203-1283)

> *The sea of Georgia and Dailam (the Chazarian Sea)* [the Caspian Sea] *is separated from all others, and is not united with any of the seas mentioned. Large rivers and springs, which never fail, discharge their waters into it. Alhaucali reports, that this sea is black at the bottom, and that it unites itself with the Black Sea under ground.*

Da Vinci (Chapter 7, The Concept of Circulation) fell into step.

> *In the Bosporus the Black Sea flows always into the Aegean Sea... The Caspian, 400 miles east, always flows through subterranean caves into this sea of Pontus* [Black]*; and the Don does same as well as the Danube.*

The misperception was to be further perpetuated by Kircher's Mundus Subterraneus (1665) world map (Chapter 15, the Maelstrom) showing subterranean connections between the Persian Gulf and the Caspian, the Caspian and Black Sea and the Mediterranean and Red Seas along the line of today's Suez Canal.

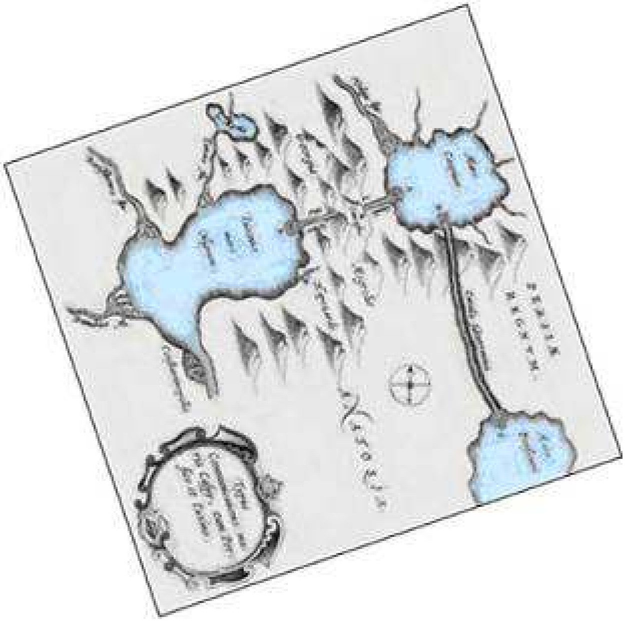


⊙ NOTAT HÆC FIG. ABYSSOS

A reason for imagining an "abysso" eastward from the Caspian is suggested in the 1902 Encyclopedia Britannica.

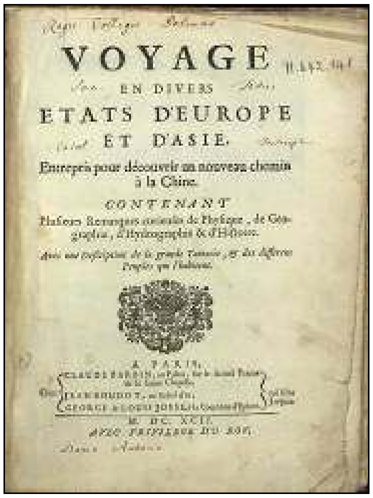
> *In ancient maps of the united Aral-Caspian Sea, two whirlpools are represented. Near the position laid down there are in the river Amu-Daria two whirlpools at the junction of several channels. These have been recently examined and found to arise from the river flowing over two conical hollows in its bed, respectively 120 and 60 feet deep; these do not appear to have been formed by running water, but closely resemble craters of mud volcanoes.*

Kircher's Typus Communicationis Maris Caspy, cum Persico et Euxino (1665) likewise shows conduits from the Caspian to both the "Mare Persicum" and under the mountains to the "Mare Nigrum." We've rotated the map so that north is upwards.



A subterranean Caspian outlet to the Persian Gulf was reported by Jan Struys in Voyages and Travels (1684), and again by Jesuit explorer Philippe Avril in Voyage en Divers Etats d'Europe et d'Asie (1692). The fact that for 1500 years, such geography was re-verified seems odd, but we should keep in mind that early travelers tended to report not only what they themselves witnessed, but what they heard in passing.

The VOYAGES & TRAVELS



VOYAGE
EN DIVERS
ETATS D'EUROPE
ET D'ASIE,
Entrepris pour découvrir un nouveau chemin
à la Chine.
CONTENANT
Plusieurs Remarques curieuses de Physique, de Géographie, d'Hydrographie & d'Histoire.
Avec une Description de la grande Tartarie, & des differens Peuples qui l'habitent.

A PARIS,

M. DC. XCII.
AVEC PRIVILEGE DU ROY.

As evidenced in the Methodist Magazine, April 1812, credence in an underground river was to persist until modern times.

> *The Caspian Sea, which receives the torrents of the Volga, and of upwards of a hundred large rivers besides, though reckoned in length no more than one hundred and twenty German*

> *leagues, and ninety in breadth, has no visible communication with any ocean, into which it can discharge its waters. Necessity, therefore, compels us to allow some secret subterranean passages through which the productions of these enormous rivers are carried off.*
>
> *This necessity will appear still more imperious, when we consider that the Caspian Sea neither ebbs nor flows; and that no visible increase or diminution has ever taken place in the quantity of its waters, though that which is brought to it annually by the Volga alone, has been deemed sufficient to cover the globe.*

The claim regarding the Volga is quite checkable. While in terms of discharge, the Volga is the world's 22nd greatest river, were its annual discharge to be spread over globe, its depth would be but 0.5 millimeter.

Kircher was considered a geologic authority long after his passing. From no less than the Scientific American of June 19, 1847,

> *Subterranean Rivers*
>
> *According to Dr. Kircher, the river Volga poured such a quantity of water into the Caspian Sea in the course of one year, that there was not some invisible outlet, it would be sufficient to cover the whole of the earth. According to his account this was in a vast cavern passing under Mount Caucasus into the Euxine* [Black] *Sea, by which the water of one sea disburdened and discharged themselves into others, and the whole kingdoms of Georgia and Mingrelia, under which they ran, were a bridge to these subterranean waters. The same was said of the Persian Bay which is said to be the reservoir of the Caspian Sea. It has also been alleged that there was a subterranean communication between the Red Sea and the Mediterranean. The Niger and the Nile are supposed to run under the mountains of Nubia. A subterranean river wends its obscure race through darksome dens and rocky cliff in the Great Schoharie Cave, and far in the caves of the Cumberland mountains streamlets roar and rush on continually. Above us and below us, the heavens and the earth are full of wonders.*

"According to Dr. Kircher..." as if he were on the faculty of Harvard.

Explanations

The bar for scientific explanation was slowly being been raised, however. (Not that high, we today might reflect, but at least to a level requiring some degree of mechanics.)

Here we have a pair of Caspian phenomena based on a stab at geochemistry.

In A Phylosophical Essay, Treating of the most Probable Cause of that Grand Mystery of Nature, the Flux and Reflux, or Flowing and Ebbing of the Sea (1673), Thomas Philipot proposed that communication between the Black, Baltic and Caspian is regulated the mechanical power of salts. Volatile salts are “check’d and depress’d” by fixed salts of "sulphur, nitre, and bitumen." so “benumb’d” that it is “impossible for the united influence of the Sun and Moon, to excite their so stupified vigour.”

In other words, salinity benumbs the sway gravity. Philipot continues,

> *The water that is treasured up in the cells and caverns of the earth, which, it is probable, here are more than ordinary copious, entice and allure back the marine waters, per motum nexus, by a motion of adherence, aggregation, union, and connection, and so by a continual circulation, reimburse and new-stock the rivers, with additional streams which are daily paid, in so profuse a tribute, to the vast exchequer of their watery sovereign.*

"Aggregation, union, and connection," according to the author, serve to maintain the subterranean flow.

The Encyclopedia Britannica of 1797 noted the underground channels' contribution to the sea's hydrocarbons.

> *It is certain that this bitumen flows from the mountains, sometimes in all its purity, and sometimes mixed with other substances which it acquires in its passage through subterranean*

> *channels, from the most interior parts of these mountains to the sea, where it falls to the bottom by its specific gravity.*

Eighteenth-century cartographer George Lowitz provided an estimate of the Caspian's elevation, 17 meters below sea level by his barometric reckoning, a determination that would cause any subterranean pipe not to draw from the Caspian, but to promptly fill it with seawater.

Following are three excerpts, one from the popular press and two from texts, dismissing the subterranean conduit for the simple reason of the Caspian's elevation.

The Scots Magazine and Edinburgh Literary Miscellany, November 1816:

> *Some years ago, Messrs Engelhardt and Permt undertook a journey to the countries that divide these two seas, partly to examine the Caucasus, but chiefly with a view to subject the relative heights of the surface of these two seas to a barometrical measurement.*
>
> *They found the difference between the surface of the two seas, 92 meters. It was the opinion of Pallas that the level of the Caspian Sea had formerly been much higher than at present. This opinion is confirmed by Perrot and Engelhardt, who place the ancient height 234 meters... above the present level; so that the quantity of water lost must be immense... They conceive that it has made its escape by means of subterranean channels, which occasionally open. But the possibility of such an escape, at least into the Black Sea, seems problematical. The surface of the Black Sea being so much higher than that of the Caspian, if any such channels had existed, the water ought to have moved the contrary way, and increased, instead of diminished, the size of the Caspian.*

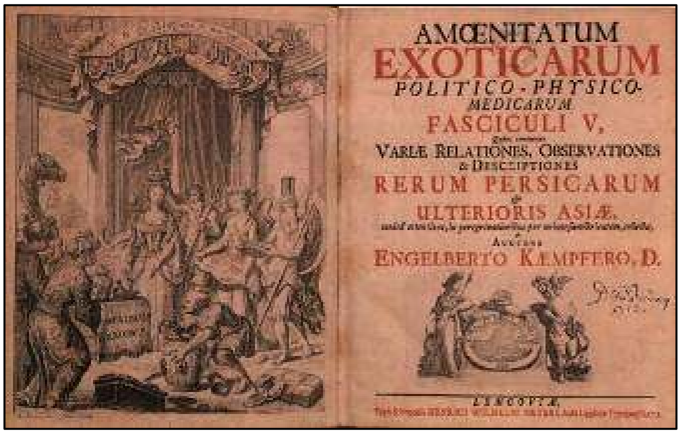
Physical Geography of the Sea (1855) by Matthew Fontaine Maury:

> *As far as we know, the level of these seas* [the Dead Sea, the Caspian and the Aral] *is as permanent as that of the ocean, and it is difficult to realize the existence of subterranean channels between them and the great ocean. Were there such a channel, the Dead Sea being the lower, it would be the recipient of ocean waters; and we can not conceive how it should be such a recipient without ultimately rising to the level of its feeder.*

School Geography (1864) by James Clyde:

> *The Caspian Sea is the largest salt lake in the world. It receives many rivers -- of which the Volga is by far the largest -- and has no outlet; yet it is gradually subsiding. The ancients supposed a subterranean channel, by which its superfluous waters were discharged into the Euxine; but that cannot be, since its level is 80 feet lower than that of the Euxine.*

An underground river was deemed unlikely for an entirely different reason by naturalist Engelbert Kaempfer in Amoenitatum Exoticarum (1712). Willow leaves found in the Persian Gulf did not need to come from the Caspian shore; the banks of the Euphrates were sufficient to furnish them.



AMŒNITATUM
EXOTICARUM
POLITICO-PHYSICO-
MEDICARUM
FASCICULI V,
VARIÆ RELATIONES, OBSERVATIONES
& DESCRIPTIONES
RERUM PERSICARUM
&
ULTERIORIS ASIÆ,
Auctore
ENGELBERTO KÆMPFERO, D.

LEMGOVIÆ,

Thanks to Edmond Halley's 17th-century measurements (Chapter 12, Superterranean Metrics) were, the magnitude of a sea's evaporation was well recognized, as noted in a pair of magazines.

The Christian Miscellany, and Family Visitor, August 1853:

> *The volume of water poured into the Caspian by the Volga, and its other numerous affluents, must undoubtedly be very considerable: it has, however, no visible outlet; and to account for the disposal of its superfluous waters, it has been supposed that these are carried off by a subterranean channel; though it is asserted by others that the evaporation from this extensive surface, comprising an area of 147,000 square miles, is sufficient to account for their disappearance,*

Scribner's Monthly, August 1871:

> *The* [Caspian Sea] *receives several large rivers into its bosom, from which they never emerge. No outlet carries off this eternal flow of water, which in olden times gave a mysterious character to it. Some dark subterranean channel was supposed to constitute the outlet; but modern science has shown that the water escapes by evaporation. Notwithstanding this endless influx of fresh water from several broad rivers, this inland sea of between six and seven hundred miles long is never freshened. Sunk nearly 400 feet lower than the ocean, as though the crust of the earth had once given way where it spreads, its yellow, turbid, tideless waters lave a desolate, sickly shore.*

As would the nearby Aral Sea disappear a century later, thus disappeared the Caspian's subterranean river. A very liquid Aral was lost by environmental mismanagement. The Caspian's underground river, on the other hand, a product of logic in itself, was at last dismissed by logic.

CHAPTER 70

ON SOME REPAIRS TO THE SOUTH AMERICAN COMPANY'S CABLE

CENTRAL & SOUTH AMERICAN TELEGRAPH Co

"Via GALVESTON"
"Via COLON"
BUENOS AIRES

AJE POR ESTAR CERRADA LA

FECHA RECIBIDO

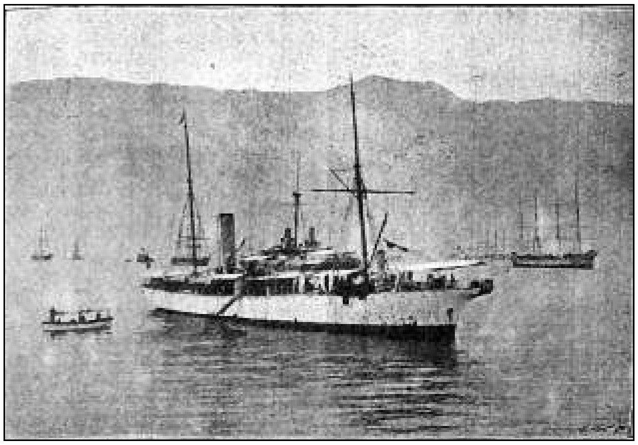
AUG
5
1914

154 LONDON 24 5PM

7.50PM S

We're in the waning years of the 19th century. Intercontinental telegraphic communication have been at lightning speed since the completion of the transatlantic cable in 1858 and now the engineering marvel is being extended by cable-laying steamships to all corners of the world.

Our story deals with the difficulties encountered in laying a 3-centimeter cable from St. Louis, Senegal, West Africa to the island of Fernando Noronha, 400 kilometers off Pernambuco, Brazil.

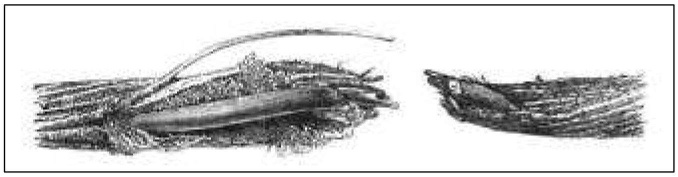


CS (Cable Steamship) Relay, belonging to the Central and South American Telegraph Company, 1898

Eastern terminus,
Pernambuco - St. Louis cable

The frustration was a series of cable breaks occurring not as the cable was laid -- an engineering problem -- but after the cable was at rest on the ocean floor and telegraphic signals had been successfully transmitted.

To the right is the break of 1893 grappled from the seabed 2200 meters below.



The paper "On Some Repairs to the South American Company's Cable off Cape Verde in 1893 and 1895" read by Henry Benest to the Institute of Electrical Engineers in 1897 and subsequent professional discussion provides insight into the era's scientific understanding of submarine springs and rivers, geology of which we introduced in Chapter 38.

Benest's presentation was reported in numerous journals:

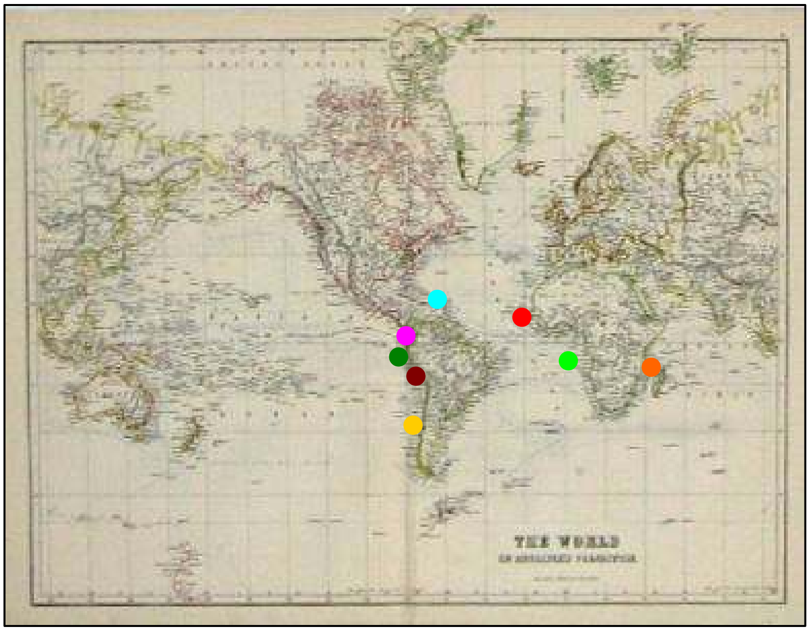
"Repairing a Submarine Cable," Engineering, March 12, March 19, March 26, 1897
"On Some Repairs to the South American Company's Cable off Cape Verde in 1893 and 1895," Electrician, March 25, April 2, 1897
"On Some Repairs to the South American Company's Cable off Cape Verde in 1893 and 1895," Journal of the Institution of Electrical Engineers, April 2, 1897
"On Some Repairs to the South American Company's Cable off Cape Verde in 1893 and 1895," Electrical Engineer, April 2, 1897
"Proceedings of Societies, Institution of Electrical Engineers, Discussion on Mr. H. Benest's Paper," Electrical Review, April 9, 1897
"Submarine Gullies, River Outlets, and Fresh-Water Escapes Beneath the Sea-Level," Geographical Journal, October 1899

To avoid excessive citations, we'll consider the above articles to be one continuous piece and likewise consolidate the published discussion (sometimes appended to the original article and sometimes in later issues of the respective journal) into that compilation. Much of the contents deals with electrical technology, but we'll confine our review to thoughts regarding submarine springs and rivers. We'll update geographic references to modern naming and employ metric units to assist comparison.

For his contribution to the profession, Benest was awarded the Institute of Electrical Engineers Fahie premium of £5, the gold coin of that denomination to the right.

Benest's report dealt with a cable break off Senegal, but the topic evoked similar stories which we'll mark on the period map.

- ● Senegal
- ● Talara
- ● Punta Pescadores
- ● Chile
- ● Ecuador
- ● West Indies
- ● Sao Thome
- ● Mozambique



Senegal

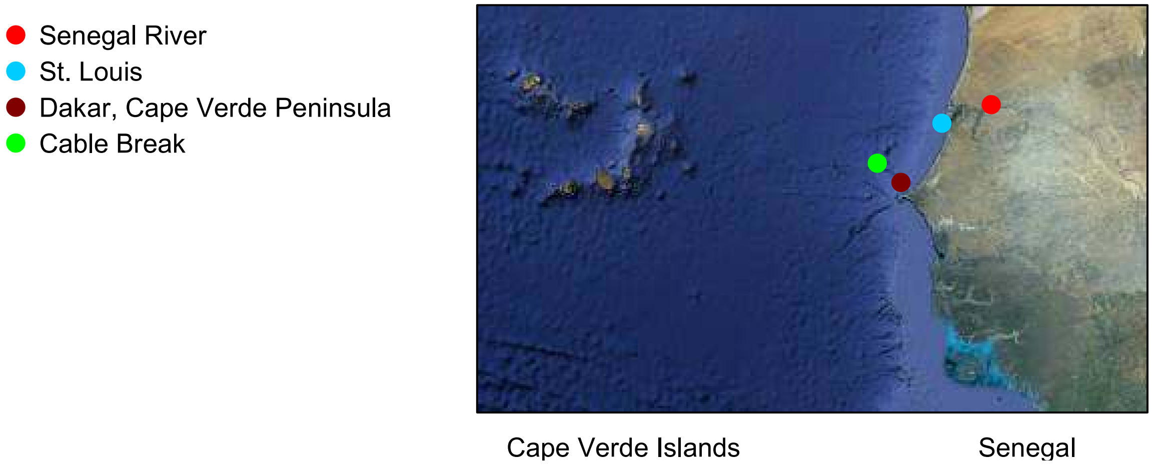
As the original portion of Benest's contribution concerned the cable breaks off the coast of Senegal, we, too, will begin there.

> *A very remarkable phenomenon, strongly favoring the theory that a submarine river outfall now exists near to Cape Verde* [the peninsula, not the islands further west]*, was witnessed during the afternoon of April 23, 1895. While engaged in grappling [for the broken cable 21 kilometers*

from the coast], the ship was gradually surrounded by great quantities of vegetable growth, having the appearance of river weed. There were also birds' feathers, pieces of orange-peel, whole and broken gourds, scraps of carpet, pieces of driftwood, small branches, etc., and the color of the sea had changed to dirty brownish green.

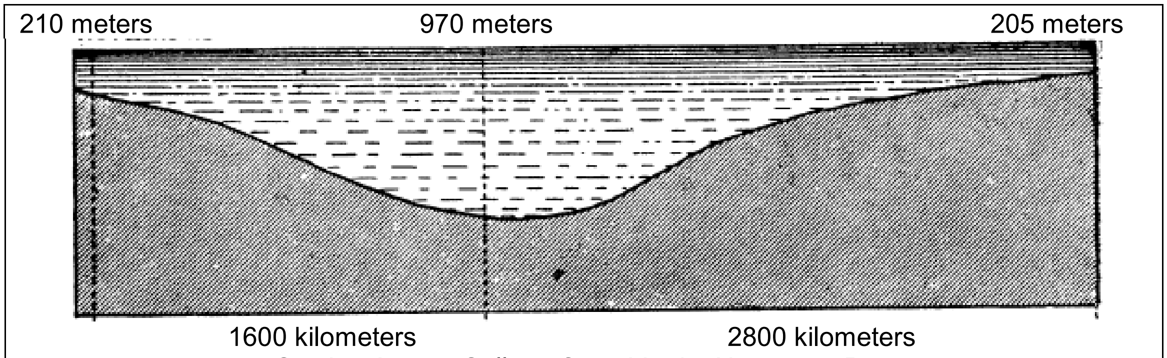
On the following morning all this had disappeared, and the sea had regained its usual tint of a pale green. The nearest surface river outlet is that of the Senegal, 125 kilometers distant in a north-easterly direction, and it would appear most unlikely that such flotsam as pieces of carpet could have been carried by the coast current, which sets to the south-south-west, to so great a distance.

If the coast current had brought these masses of weed and refuse of human habitation out of the Senegal River, it would have been a more or less constant and familiar appearance, as would also the color of the water; but the discoloration of the sea-surface with the accompaniment above described was local, and would appear to be due to a sudden outburst of river-water in the vicinity and below sea-level.



Well-known authorities agree that in the tropics the month of March is a rainy month, therefore it is fair to assume that heavy falls of rain take place about this period in the unknown interior of Africa and America; while on the shore-lines near where the cables have been broken, there is nothing but sand for miles around,, and comparatively little rain. The rains from the interior find their way to the sea by surface rivers in some cases, and by subterranean rivers, in all probability, in others, their subterranean flow being not merely percolation through porous strata, but large volumes of water flowing through caverns and crevices in the Earth's crust. These volumes of water have their source in the mountains, and find their outlets at sea.

The river shown on the map of Cape Verde point is probably a small stream fed locally, but the lagoons are created by springs from artesian water. Then, carrying the eye from these lagoons to the sounding of 420 meters, a crust of water-covered shore sand will have been traversed, and seaward of the 420-meter spot there is the head of a large gully. That gully, by the formation in its neighborhood, could never have been formed by a surface river, because one finds 420 meters increasing almost precipitously to 1100 and 1280 meters. Mr. Gray believes that at about 1100 meters from the surface, and at about 110 to 130 from the bottom, the outlet of the river will be found, and that at certain seasons, in the month of March probably, a geyser-like effect is produced.

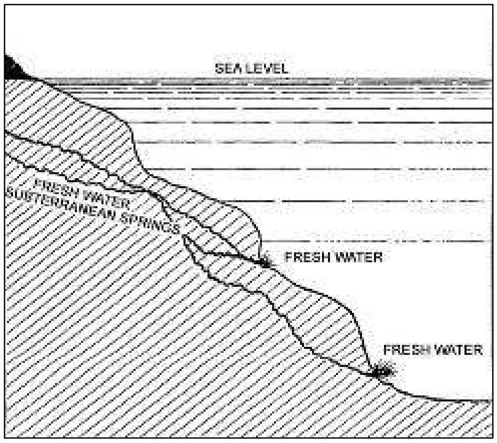


Section Across Gully at Cape Verde, Narrowest Part

> *A river, the higher reaches of which are crossed the railway between St. Louis and Dakar, now discharges, in the wet season, into these lagoons, but in the dry season the water disappears in the sandy bed before reaching the neighborhood of the coast. Water is always present; the river exists behind these lagoons which are in a direct line between that river and the head of the gully. These facts are significant of a former surface outlet, and a submarine connection between river, lagoons, and the sea at the present time.*
>
> *The limits to which water gravitates into the earth is beyond the powers of direct observations, but, as it is known from the formation of many basins, that the strata of which they are composed reaches a thickness of from 6200 to 9400 meters, it is reasonable to infer that they are permeated by water to an equal depth. It would be equally reasonable to infer from this, that artesian outbursts may, and very likely do, occur at various depths in which submarine cables are laid.*

Benest's assertion of the submarine spring drew a multitude of responses.

The Journal of the Institution of Electrical Engineers produced a graphic, entirely correct in today's understanding.



Robert K. Gray noted that within the last eight or ten years, "Capt. Martele" [the Martel of our Chapter 49, Subterranean Watercraft] had been making "considerable investigations in the direction of cave hunting" and there was no reason why limestone should not exist under the sea. Subterranean conduits egressing from the submarine continental slopes may indeed be "the cause of cable interruptions which occur at the period of the year which coincides with the season of heavy rains in the interior."

The remedy for the cable problem, concluded Gray, would be placing the cable at an elevation higher than the outlets, "so that the intermittent vomiting of terrigenous debris, though continuing to cause submarine landslips would no longer find a cable laying at right angles to its path."

Sir Henry Mance, President of IEE, saw no reason why there should not be fresh water streams 200 or 300 kilometers from shore, but judiciously withheld calling them rivers.

> *Now, without giving these submarine fresh-water streams the dignity of calling them rivers, we may easily imagine (in fact, we know to a certainty they exist) streams of water making their way for many miles out to sea before breaking ground.*

Mance was extravagant in his estimate of distance, however, as the conduits would have been formed before submersion. The world's longest terrestrial karst systems extend no more than tens of kilometers as the crow flies, and that's with occasional breaks to the surface. The highest sub-sea level karst opening would preclude submarine flow further down the pipe.

James Anderson, another Knight of the British Empire, expressed no doubt that submarine streams are the cause of cable failure.

But there were those who disagreed with Benest's contention, and generally for valid reasons.

Mr. W. H. Precce found proof lacking for a submarine river, but rather that Benest had proven the existence of a submarine current. The proliferation of journal discussion only confirmed the writer's long-held contention that "it was absurd to lay a submarine cable unless something was known of the bottom on which it was to rest."

Admiral Sir William James Lloyd Wharton, hydrographer to the Admiralty, doubted --and correctly so, we add --that there would be sufficient head behind a submarine outflow to move matter violently along the sea bottom and he thought some other cause must be sought for the power to move sea bed matter. Nobody, however, seemed to recognize the admiral's logic.

Mr. Chas. Bright was likewise not in agreement with Benest's submarine spring culpability.

> *It was highly improbable that pieces of carpet and other refuse of human habitation should be discharged from an artesian well. The proximity of the month of the Senegal River was a more likely explanation of the appearance of these fragments.*

The bulk of discussion then turned toward reports elsewhere. We'll begin with those from Peru.

Talara, Peru

> *Reverting to the subject of cable repairs as being the indirect source of our knowledge of underground rivers having their outlets under the sea, a remarkable experience occurred during a repair conducted by Captain Lugar of the Central and South American Telegraph's Company steamer Relay to the cable connecting Paita, in Peru, with Santa Elena, in Ecuador. The fracture had been located at about 15 kilometers west from the small harbor of Talara... The section of cable affected was noted for the regularity of its rupture nearly every year, about the end of March or early in April. The weather was fine, with light breezes and smooth water; in fact, in this locality gales are unknown, and rain seldom falls near the coast; but, beyond 80 kilometers inland from Talara, at times the downpour is exceedingly heavy.*

Seasonal correlation between inland precipitation and submarine cable breaks was a perception shared by many.

Proposition:	When A, then B for reason C	where,
Observed:	Cases of A and B	A = Terrestrial flood season
Observed:	Cases of not B and not A	B = Submarine cable break
Therefore:	C	C = Cable snapped by submarine flood surge

To test the logic, let A be Easter, B be showers and C be precipitation caused by Easter eggs.

The next excerpt falls within a larger collection of underground river lore, detailed reports attributed to unnamed observers.

> *Some few months later, during a conversation with one of the officials of the Talara Petroleum Company about the nature of the bottom outside their harbor, this gentleman informed Captain Lugar that a Peruvian half-caste he had employed at the wells asserted that beyond the Amotape mountains, which lie at the back of Talara, there exists a chain of lakes which has an outlet through a hole in the mountain-side, and that canoes and paddles lost on the lakes had been found on the coast between Talara and Parina point. This evidence certainly goes far*

> *towards proving the existence of a submarine river in this particular locality, and the period of the greatest outflow would appear to be in the months of March and April. These months coincide with the time of the heaviest of the rainy season in the Cordilleras and Amotape ranges.*

Artifacts -- canoes and paddles, in this case -- lost on lakes and found on the coast are a staple of underground river legend. While the testimony of a "half cast" alone might be dismissed by the readership, that both an official of a business firm and a sea captain deem the report worth repeating affixes a stamp of legitimacy.

Punta Pescadores, Peru

Several of the following paragraphs seem to concern the same cable failure, not all. In any case, the story's the same. As with the Gospels, it can take multiple accounts to chronicle a saga.

> *Another remarkable experience has been communicated by Captain D. Morton, who was at the time (March, 1884) in command of the West Coast of America Telegraph Company's steamer Retriever. During a repair to that company's cable on March 4, 1884, in 1200 meters of water, 19 kilometers off Pescadores point, and while picking up towards the break, and when close to it, the cable came up completely surrounded with twigs and branches of olive trees to such an extent that they bad to send men over the bows with axes to clear them away so as to allow the cable to come in over the bow-sheave.*
>
> *The Ocoña River, 21 kilometers north from the position of the break, does not flow into the sea, but into a basin or lagoon a quarter of a mile from the sea, and during heavy rainstorms in the mountains this river is transformed into a torrent carrying everything with it. Rapidly pouring into the basin or lagoon, it raises the water-surface above the sea-level, and no doubt, when a certain pressure is relieved by the water in the basin or lagoon again reaching the sea- level, a subsidence of the sea-bottom takes place, carrying the bight of the cable with it. The nearest river outlet flowing into the sea is the Quilca River, 85 kilometers east-south-east from Pescadores point.*

It's odd how the Ocoña is dismissed with such ease, as seamen of the day would have known that flotsam can drift much further than 85 kilometers.

> *Mr. E. W. Parsone relates that, during some cable repairs carried out... in the neighborhood of Pescadores. The cable at this spot was repaired many times, and ... was got up with difficulty, bringing up with it masses of branches and trunks of trees, which had to be cut away with axes before, the cable could be got inboard. These branches and boles were the remains of olive trees, which do not grow along the coast; they doubtless came from the Arequipa district* [i.e., the Quilca]*, some 130 kilometers inland, where olive groves abound.*

Masses of branches and trunks of tress "disappeared... underground to emerge at sea by a submarine exit" adds drama, and as we appreciate olives, we feature of the Peruvian green variety

> *It would appear that these remnants of vegetation had drifted with the surface river water from the interior, and had disappeared with it underground to emerge at sea by a submarine exit. To support this idea, the breaks in the cable generally occurred after freshets due to rain in the interior. The cable was eventually diverted towards the shore, and no further trouble has been experienced, which would seem to prove that the cable had been laid shoreward inside and above the submarine river outlet.*

It's the same A-B-C logical error as before.

The next excerpt isn't about a cable break, per se, but rather an on-shore observation.

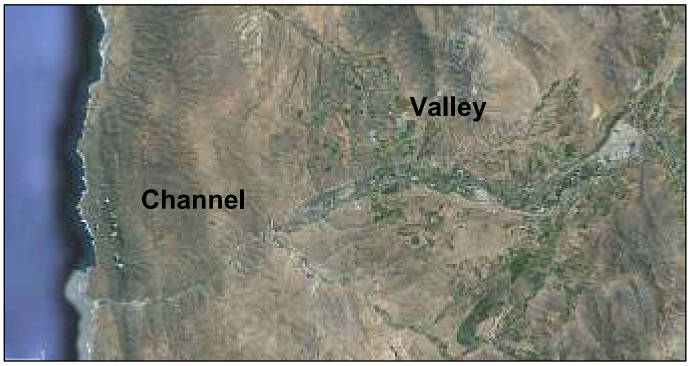
> *A very remarkable instance of a river having its course underground exists to the north of Arica, a port on the coast of Peru* [today part of Chile]. *The bottom of the river valley consists of loose sand, no evidence of water being apparent. At a depth of some 5 meters, however, a firmer stratum of sand is found, and a continuous current of fresh water is distinctly observed as the water rapidly filters through the sand into and out of the pit. This subterranean stream is met with as a rapidly flowing river some distance inland and among the higher foothills of the great mountain ranges, but speedily disappears on entering the sandy and rainless coast region again.*

Here we've nothing remarkable by any measure -- a losing stream in an arid region that feeds an aquifer 5 meters lower which in turn seeps into ocean -- inserted into the cable debate.

Chile

> *During the month of October, 1878, the West Coast of America Telegraph Company's steamer Retriever, then newly out from England, under the command of the writer, repaired the section of cable between Valparaiso and La Serena... The writer was told, after the repair in 1878, by people... well acquainted with the Limari valley, that, during floods inland in the winter season, this river rose and inundated its banks for many miles, carrying away cattle and buildings, shrubs and trees, but none of these could possibly have escaped to sea through its surface outlet.*

Why the flood debris couldn't wash to the sea -- a dubious pronouncement, given the visible channel -- we're not informed.



Ecuador

> *The Central and South American Company's officials off Point Esmeralda, in Ecuador, had a similar experience, and surmounted the difficulty by laying the cable above the supposed submarine river outlet.*

We've a similar problem (a submarine cable break), a remedy (replacing the cable with one at a higher elevation), and the inference of causation (a submarine river outlet). Again the A-B-C logic.

West Indies

> *Captain Lugar cites one other instance of a submarine outburst of fresh water which had come under his personal notice off the Dutch island of Saba, a volcanic cone 470 meters high, 66 kilometers north-west of St. Kitts, in the West Indies. He visited by boat a spot in the sea about one-third of a mile from the shore on the south-west side of the island, and saw the fresh water bubbling up in small circles. He sampled some, and found it brackish to the taste. The native who guided him to the spot averred that sloops and schooners frequently filled up their barecas from this submarine stream of artesian water... He thought this suggested that there were such things as submarine streams and that cables were broken by them.*
>
> *Mr. H.C. Donovan related a case of a West Indian cable repair in comparatively shallow water. Considering the cable had been down only four years, it was surprising how it was coated with vegetable growth. In deeper water, however, as they got to the break it was scoured, and*

> *presented signs of severe distress. The galvanized iron was scoured bright. That was between Martinique and Dominica, in 2900 meters. There could be no question of any rivers there. He, however, knew of various cases of brackish water due to submarine outflows.*

As the West Indies have both karst aquifers and thermal vents, it is indeed conceivable that water might well up in the shallow offshore, though there's no modern marine springs sufficient to provision a ship. A karst outlet could not sever a telegraph cable, but as the region is volcanically active, it stands to reason that a seafloor tremor might part a taunt cable.

Sao Thome

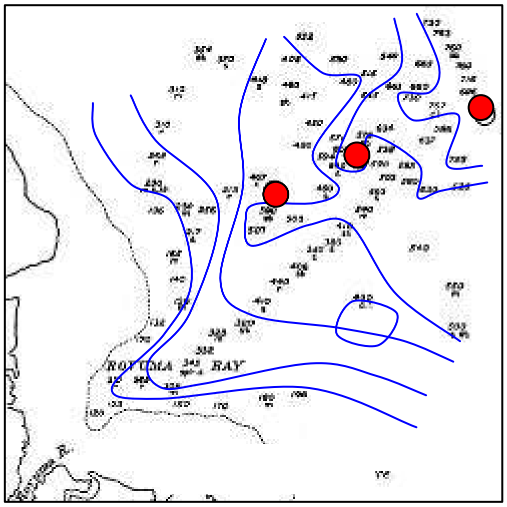
> *Immense masses of mud are in continual movement off the Congo River, and extend to some hundreds of miles to the westward; but here is a very deep river debouching right into the sea, and scouring out a channel hundreds of fathoms in depth. The West African Telegraph Company's cable between Loanda* [modern Gabon] *and the island of Sao Thome has been broken seven or eight times since its laying in 1880, and some hundreds of miles of cable have been used in repairs.*

The mighty Congo is feared to be slicing open the seabed, decimating whatever lies in its path.

Mozambique

To the right is the survey of Romuva Bay reported by Benest, the 100-fathom (183-meter) contours added. The three cable breaks (red circles) lie within the trough.

> *On other similar occasions a like course had been adopted, notably off the Rovuma River, in the cable between Zanzibar and Mozambique. The last mentioned of these two cables broke down eight years in succession. Since it has been relaid inshore, some twelve years ago, it has never broken down, and this is doubtless due to the cable being laid shoreward of the submarine river outlet, which probably still continues to periodically throw out its debris.*



Once again, the A-B-C logic.

> *Captain Lugar: Off the Rovuma River on the East Coast of Africa... similar conditions have been met with in repairs to telegraph cables... Much trouble had been experienced with the cable between Mozambique and Zanzibar, and the conclusion arrived at was that the cause originated in fresh water making its way to the surface from the sea-bottom, disturbing the ground and fracturing the cable.*

The Captain is correct that fresh indeed rises, but he's incorrect that it does so at a cable-fracturing velocity.

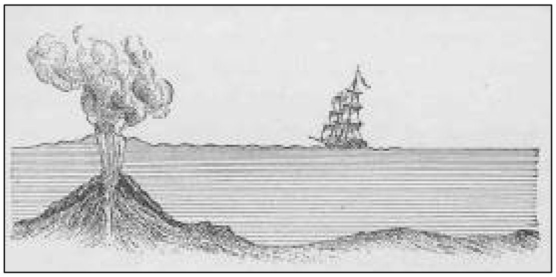
The Chairman's conclusion

The Chairman's summary, per the 1897 minutes of the Institute of Electrical Engineers,

> *Benest's theory that the cable breaks, described in his paper, were caused by a submarine river found a number of supporters, though the majority of the authorities appeared to think the evidence was insufficient.*

But if submarine rivers were not to blame, why, then, did the cables break?

Were the breaks due to submarine volcanoes?



An illustration from Sonrel's Bottom of the Sea (1872)

From the discussion of Benest's contribution,

> *Mr. Pierce said the paper... showed how much geographers were indebted to telegraph engineers. He considered that the high temperature at the sea bottom was evidence of the existence of a current, though it perhaps was not sufficient to prove the existence of the Benest river... He had no doubt that cables were sometimes broken by volcanic agency, and instanced some examples on East African and Australian cables. The proposed Pacific cable would run over a region known to be subject in some parts to volcanic action, and, therefore, it was of the greatest importance that a previous survey should be made of the sea bottom. In a paper read in 1859 he had said that the sea bottom should be surveyed before a submarine cable was laid. His proposition was met by the derisive laughter with which ignorance always greets words of wisdom, but since then wisdom had, as usual, been justified of her children.*

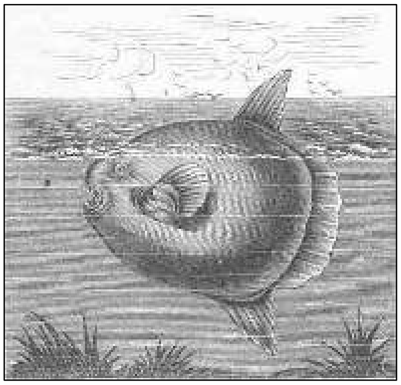
We applaud the concluding sentence regarding ignorance. A further century of cable laying, however, has never spanned a submarine volcano.

Were the cables broken by whales?

"A Whale Breaks a Submarine Telegraph Cable," Scientific American, December 14, 1889, described an experience of the Western and Brazilian Telegraph Company's CS Viking.

> [The vessel] *brought up to the surface a monster dead whale, measuring about 50 feet long, intact with the exception of the upper part (the belly) from which all skin had been worn or eaten away... The tail of the whale had two complete turns round the shank and three or four across the flat or fan part.*
>
> *The above, by Mr. Peters of the Viking, is the third instance in which whales have broken telegraph cables... The supposed cause is that the cables were hung like festoons through being laid too tightly over uneven ground, and that the whales used them as rubbing posts.*

Were the cables severed by other sea creatures?



From "Dangers that Beset Submarine Cables," New York Times, July 6, 1878,

> *In many cases, owing to the inequalities of the bottom or the sea, the wires... hang like festoons. Then they are liable to accidents from the larger denizens of the sea, among which we may particularly mention the sun-fish (Orthagoriscus). When swimming it turns round like a wheel and moves with great rapidity... Specimens have been caught weighing 500 pounds... Not long since the interruption occurred in a cable, on examination it was found that it had been penetrated by one of the caudal spines of the sun-fish.*

Or were the cables broken by turbidity currents, a phenomenon described in Chapter 42, Submarine Springs and Rivers?

A 7.2-magnitude earthquake off Newfoundland in 1929 triggered a submarine landslide of 200 cubic kilometers in volume down the Grand Banks slope, snapping a dozen submarine telegraph cables in route, the sequence of which provided the 40-80 kilometers/hour estimate of flood-pulse velocity.

Following a cable break off Columbia's Magdalena River in 1935, cable retrieved from 1500 meters had large masses of shallow-water marsh grass twisted around it, evidence of extensive sub-oceanic sediment flux.

Like cable failures yet to occur elsewhere, the South American Company's difficulties seem to have been due to turbidity currents, infrequent in occurrence, but massive in submarine havoc.

But as we're well aware, it's hard to rid our imagination of streams blow. From "Fallacy of the Deep-Sea Erosion Theory," Surveyor and Municipal and County Engineer, October 12, 1906, by Gerald Case,

> *In very deep water telegraph cables have been broken and buried under large masses of materials. Such local displacements of the ocean floor are due to earth movements and also to submarine springs.*

And from where did Case draw his submarine springflow add-on, we ask?

From "On Some Repairs to the South American Company's Cable off Cape Verde in 1893 and 1895."

As with much lore of underground rivers -- under the land, under the sea, it matters little -- refuted conjecture again and again reworms its way into our knowledge base.

CHAPTER 71

SUB-SAHARAN STREAMFLOW AND SHAMBHALA

In this chapter we will visit an underground river in Africa and another in Asia. In both instances, however, we will concentrate not as much on documenting the local lore as in observing how such stories reinforce like concepts of Western culture.

Sub-Saharan Streamflow

We encountered Pliny the Elder in Chapter 3, where the Roman geographer wrote of a marvelous underground river flowing eastward from what is now Morocco to a lake in what is now Algeria or Tunisia, then sinking once more and re-emerging as headwater to the Nile.

In this chapter we'll not argue hard for the Nile connection, but we'll look a bit more closely at the middle reach of Pliny's river, the portion that would cross -- perhaps over, perhaps under -- the Sahara. We may think that part unlikely also, but, as we will see, many have argued for its existence.

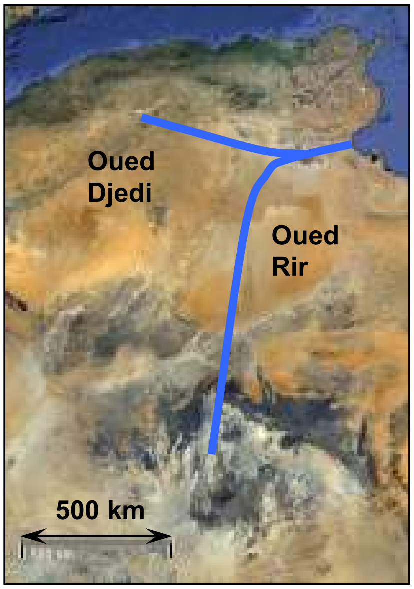
In the sixth century, Olympiodorus of Alexandria wrote of 200-meter wells across the Sahara. In speaking of the spouting wells of the Sahara, 14th-century Tunisian historian Ibn Khaldoun considered them "a miraculous fact."

Not that long ago in the course of history, we must conclude,

By the time of documentation by European geographers, evidence of Sub-Saharan waters was scant, but speculation remained of subterranean waterways. "Artesian Wells and the Great Sahara," Popular Science Monthly, February 1880, by Seaton Schroeder, designates the dry wadis of the desert as "underground streams" having histories of surficial flow.

> *Nearly all the fluvial network of the Algerian Sahara converges toward the Igharghar. Formed by the confluence of several small streams on the slopes of the Ahaggar, it flows northward, and soon sinks through the light sands and pursues its underground course to the western part of the basin that the French contemplate inundating, bearing in that part of its course the name of Oued Rir, or River Rir. Into this same depression flows another subterranean stream, the Oued Djedi, which has its sources on the plateau of Laghouat in the west. The two streams in all probability united in past ages, and possibly even connected with the Mediterranean.*

The Algeria/Tunisia map to the right indicates the locations of the supposed ancient free-flowing rivers, uniting and connecting with Mediterranean.



The careful reader who noticed the phrase, "that the French contemplate inundating," is to be congratulated on his or her attentive reading. We'll return to this alarming-sounding contemplation later in our chapter.

The French

While stories of a great Sub-Saharan river have been told since antiquity, we will not re-enter the chronology until the time of French colonialism in the mid 1800s. The French "explorateurs" were quick to note Saharan soils rich in nutrients, lands prime for irrigation.

A significant perceptual difference between the French tapping of underground waters and what was likewise occurring in the United States -- the subject of chapters to come -- was that the French reasonably understood with what they dealing, while most American farmers did not.

As groundwater hydrology (Chapter 38) had its scientific roots in 18th-century French academics, an officer of the French Foreign Legion was likely to recognize a natural fountain in an otherwise-arid landscape for exactly what it was, a "fontaine artésienne," not a "rivière souterraine." In subsequent chapters dealing with water in the American west, the popular reporting will contain less stratagraphic edification and more fanciful tales mysterious below-ground rivers.

"Wells in Sahara," New York Times, September 17, 1882, illustrates the French attention to permeability, inclined aquifers and aquicludes, the precise sort of geologic metrics required for successful water resource development.

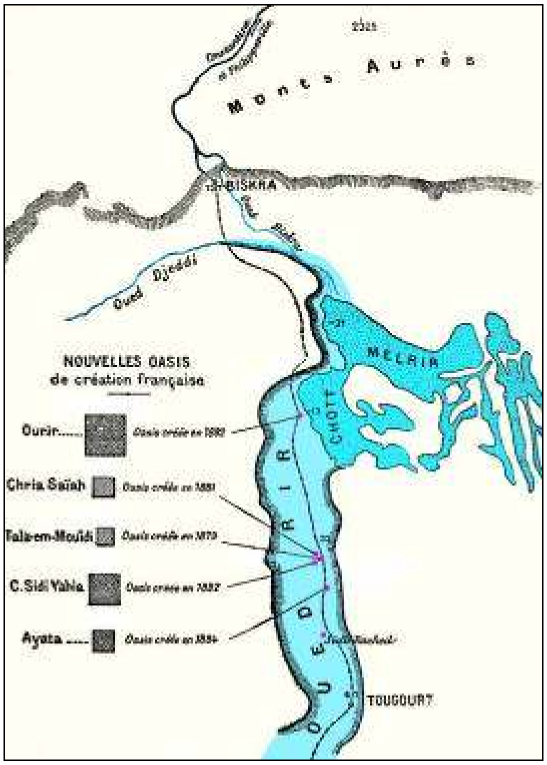
> *As for the rocks which underlie the sandy deposits, what we know of them is due to numerous wells sunk by the Frenchmen all along the northern boundaries of the Sahara, particularly in the Province of Constantine. The learned engineer, M. Jus, who during 20 years has directed those admirable works, ranges in the Pliocene formation the different rocks, limestone, sandstone, marls, gypsum &c., crossed by the soundings, as well as the impermeable water-bearing clay which forms at the bottom of wells. This clay presents the most astonishing discrepancies in its level, being sometimes many hundred feet under the surface of the soil, and sometimes approaching it very near. So for instance, in the region of the Oued Rir, two wells named Ain-Kerma and Un-el-Thier, are distant one from the other about 40 miles, and still the depth of the first is only 44 feet, and that of the second 321 feet.*

In "Artesian Wells and the Great Sahara," Popular Science Monthly, February 1880, Seaton Schroeder describes the French well-drilling success at Sidi Rached.

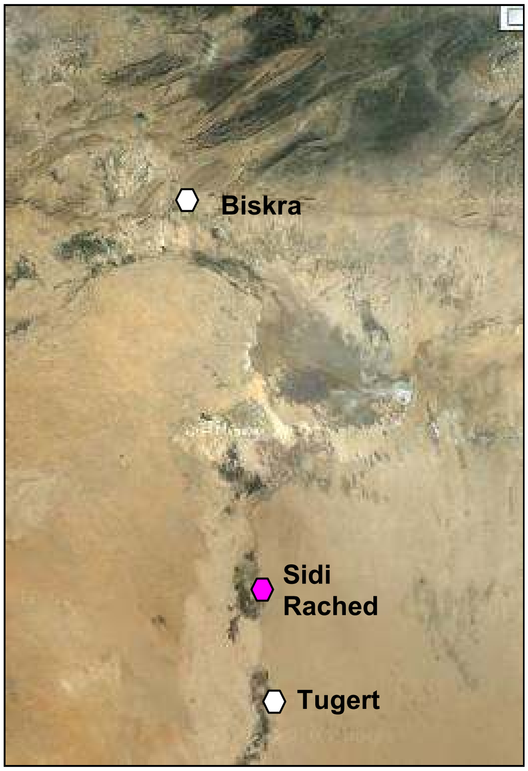
> *General Desvaux, however, commanding the subdivision of Batna, kept studying assiduously to find means of fertilizing the barren regions around him.*
>
> *He experienced some delay, of course, but finally in 1856 the material arrived at Tamerna, and on the 1st of May of that year the first blow was struck by Ali-Bey, the Caid of Tugert. The work was pushed rapidly forward, and on the 9th of June water issued in volumes. Lieutenant Rose, of the French army, describes the scene as being most affecting, comparing it to the miracle of Moses drawing water from the rock by the touch of his rod; the old sheik prostrates himself, mothers bathe their children in it, and it is blessed and named the Fountain of Peace. The issue of water was 69,725 gallons a day, temperature of 70° F.*
>
> *In eight years, 1856 to 1864, the French Government established in that vicinity (between the Ziban oases and the river Rir) seventy-two artesian wells, of which twenty-four had been previously abandoned in course of execution by the natives... The deepest was at Chegga, 364 feet; the least depth at which water was found was twenty feet. The ordinary depth was between 160 and 225 feet, and the average temperature 76° F. The largest issue of any was 1,267 gallons a minute from that of Sidi Amran, 255 feet deep.*

By the end of 1879, 434 wells had been bored by the Arabs and 68 by the French between Biskra and Tugert.

The map below shows French artesian wells in the wadi of the Oued Rir. For reference, Biskra and Tugert are 200 kilometers apart.

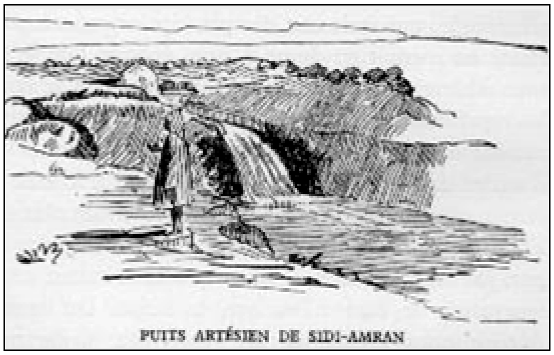

Monts Aurès
Biskra
Oued Djeddi
Melrir
Chott
Oued Rir
Tougourt
NOUVELLES OASIS
de création française
Ourir
Chria Saïah
Oasis créée en 1881
Tala-em-Mouïdi
Oasis créée en 1879
C. Sidi Yahia
Ayata
Oasis créée en 1884

L'Oued Rir et Ses Nouvelles Oasis de Création Française (1889)

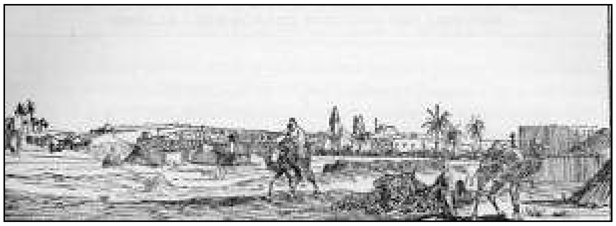

Biskra
Sidi Rached
Tugert

Modern Aerial Photo

Below are two of the French successes.


PUITS ARTÉSIEN DE SIDI-AMRAN

Sidi Amran (Sidi Rached) Oasis



Tugert

Sketches from Gabriel Hanotaux and Alfred Martineau, Histoire des Colonies Françaises et l'Expansion de la France dans le Monde, (1932)

Such news was of great interest to Americans, and in an era of free-wheeling journalistic plagiarism, stock news items circulated freely and not uncommonly, even reappeared in the same newspapers as new news.

Two news clippings illustrate the popular reporting, each identifiable by its poetic title and each retrievable from any number of archived periodicals.

> *Modern science is literally making "the desert to blossom as a rose." In the great desert of Sahara in 1860, five Artesian wells had been opened, around which, as vegetation thrives luxuriantly, thirty thousand palm trees and one thousand fruit trees were planted, and two thriving villages established. At the depth of a little over five hundred feet, an underground river*

> *or lake was struck, and from two wells live fish have been thrown up, showing that there is a large body of water underneath.* -- "The Desert to Blossom as a Rose," Scientific American Mar 12, 1864
>
> *Perhaps no more hopeless enterprise could be undertaken than to attempt to reclaim the great African desert of the Sahara, where no rain ever falls, and there are but occasional oases to give relief to the weary and fainting caravans that traverse it. Modern science, however, laughs at seeming impossibilities. Skillful engineers in the French Army in Algiers proposed to sink Artesian wells at different points, with the strong confidence that thus water could be reached and forced to the surface. In 1860 five Artesian wells had been opened, around which, as vegetation thrives luxuriantly, thirty thousand palm trees and one thousand fruit trees were planted, and two thriving villages established. At the depth of over fife hundred feet, an underground river or lake was struck, and from two of them live fish have been thrown up, showing that there was a large body of water underneath.* -- "In the Wilderness," The Friend, a Religious and Literary Journal, May 21, 1864

Numerous American newspapers drew upon the correspondent of the Moniteur de l'Armes, a French military newspaper, to report upon the piercing of the well at Sidi Rached.

> *At the moment of water bursting forth, no Arab was present, but the news quickly spread, and in a few minutes the whole population of the village rushed to the spot and threw themselves upon the works with such frenzy that force was necessary to remove them. Women and children lay down in the stream, as if they had never seen water before. The Sheik of Sidi Rached could not repress his emotion; he threw himself on his knees by the trough and wept for joy. The next day the inhabitants of the neighboring Arab villages cam to thank the engineers and to bless then fountain, while in the evening there was a dance and great merry-making, and this festival was kept up for six days.*

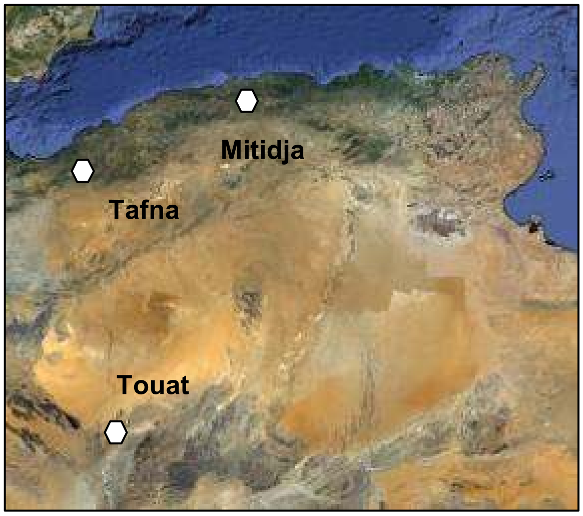
We can safely say that most Americans in 1864 would have been exposed to some version of the Sidi Rached story. Readers would have enjoyed the account of live fish and the belly-dancing harem (though it didn't exactly who was dancing or what was being danced). Given our retention of envisionable information -- we'll have more to say about this in Chapter 90, Why Do We Believe What We Believe? -- the description, "an underground river or lake," would have persisted as well.

Many American children would have been somewhat informed on the topic, as well, thanks to periodicals aimed at their readership. Take, for example, the Christian Advocate, February 26, 1880, "Our Little People's Club, A Talk by the Professor."

> *In the great African Desert of Sahara deep wells... were dug long ago, the present inhabitants doing no more than to keep them in repair. Gangs of men, called Kertassas, go about to cleanse these wells from the sand which soon chokes them up. They are useful indeed, for the traveler depends on the oases in which they abound for the water to help him over the scorching sands. The wells are what we call artesian, where water rises to or above the ground in a jet. A Kertassas would look strange enough to a member of our Club. He is emaciated to the last degree, showing how severe his work. The process of clearing a well is thus described.*
>
> *When the well is to be "cured," a gang of Kertassas is employed, and one of them prepares his windless to make the descent. First, he stops up his ears with wax, and rubs his head for awhile with the cold, brackish water. When his system has recovered from the shock, he invokes the blessing of Allah and is lowered down, carrying a basket. In tow or three minutes he gives a signal, and is drawn up, with his basket, which he has filled with sand. While he is resting and warming himself, another descends in like manner; and so on alternatively through the whole gang.*
>
> *The work is very exhausting, and most of the older Kertassas are mere skeletons, but they endure the work better than their younger companions. Frequently when drawn up they are perfectly livid, bleeding at the nose, then pulse having fallen to fifty-five beats in a minute. Each gang consists of six or eight men. Their pay is about ten cents a basket; and a man cannot*

> *make more than six descents in a day. As it requires from two hundred and fifty to three hundred basketfulls to clear out a well, the operation is a long and tedious one, and it must be repeated every three or four years.*

Mr. Rogers would have toned down the physiologic aspects, however, for his viewership a century later.



French development was not confined to the Oued Rir. We'll mention three additional wells.

Haouch-Baraki was on the Mediterranean plains of Mitidja. From (but as are most of our news clippings, not at all exclusively) the New York Evangelist, June 5, 1862,

> *In a well sunk at Haouch-Baraki, in the plains of Mitidja, at about 137 yards, a jet of water was met, giving 120 gallons a minute. The boring continued to 154 yards, the supply of water was increased, and rose above the soil.*

The next report, "An Underground Lake," New York Times, July 27, 1879, seems somewhat Sinbadian (our Arab hero of Chapter 16, Underground Rivers in English Fiction).

> *The Tlemcen Courier (Algeria) describes a wonderful discovery recently made at the picturesque cascades of that place. Some miners had blasted au enormous rock near the cascades, and, on removal of the debris, found it had covered a large opening into a cave, the door of which was covered with water. Constructing a rude raft and providing themselves with candles, the workmen sailed along this underground river, which, at a distance of 60 meters was found to merge into a large lake of limpid water. The roof of the cavern was very high and covered with stalactites, the brilliant colors of which sparkled under the light of the candles. Continuing their course, tile workmen and at certain places to navigate their craft between the stalactites, which, meeting stalagmites from the bad of the lake, formed enormous columns, which looked as If they had been made expressly to sustain the enormous arches. They thus reached the extremity of the lake where they noticed a large channel extending toward the south, into which water quietly made its way. This is supposed to be a large fissure which has baffled exploration hitherto at Sebdou, and which connects the cascades with that locality, and thus with the mysterious sources of the Tafna. It is possible that here they have found an immense natural basin, supplied by powerful sources, and sending a part of its waters toward the lake, while the rest goes to Sebdou. The workmen estimated the distance underground traversed by them at three kilometers, and the breadth of the lake at two*

Since that report, however, such a North African waterway hasn't been rediscovered. What seems more likely than a large underground lake is journalism shaped by discoveries in American karst regions, of which we'll peruse in subsequent chapters

Frank G Carpenter's "Through the Garden Spots of Great Desert of Sahara," Atlanta Constitution, April 28, 1907, employs

> *Much of the desert has a bed of stiff clay under it. The water may sink down through a hundred or more feet of gravel and rock, but when it comes to a clay bed it flows on until it strikes a hollow and if the hollow is high enough and deep enough, the result is an oasis. In the district known as El Erg depressions of this kind furnish wells which can irrigate eight millions of date palms, and where I am not is the Wadi Sacora, a great underground stream which flows far*

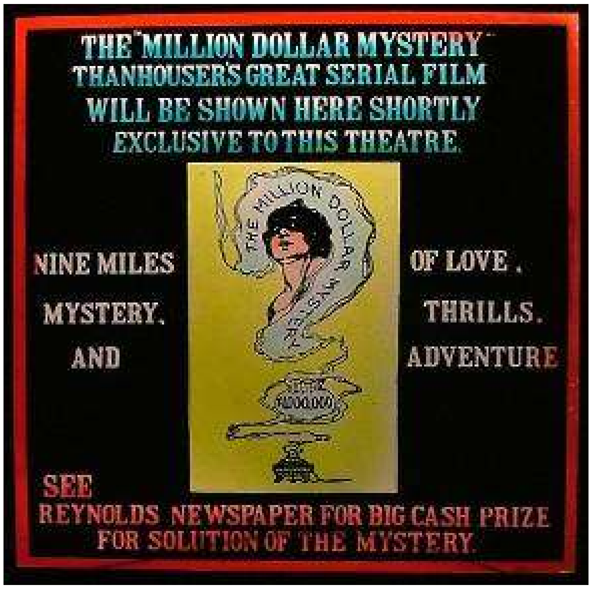
> *below the surface for several hundred miles and then rises and supplies the oases of Touat, which are among the largest of the western Sahara.*

We're unsure if the descriptions of a "hollow... high enough and deep enough," and "a great underground stream" are metaphoric or otherwise, but the imparted impression -- as we will see time and time again in the popular press -- is more dramatic than the sandy and grimy reality.

If nothing else, the title "The Underground River of the Oasis," Popular Magazine, November 7, 1923, by James Francis Dwyer enhanced a hydrologic impression. The article was written when Dwyer and his wife traveled throughout the Middle East and Africa, producing a story for every issue of the bi-weekly magazine.

In addition to oft-speculative news reporting, there's the Saharan underground river fiction. In Chapter 21, Boys Club Singles, we quoted from S. Fowler Wright's, The Hidden Tribe (1938). Below the Sahara, or Frank Reade, Jr. Exploring an Underground River with his Submarine Boat (1896) by Luis Senarens, another Chapter 20 author, would be another example of the popular dissemination of desert lore.

"The Million Dollar Mystery" (1914) was a 23-episode film serial and run in more than 200 newspapers. The plot was one of international intrigue revolving around a millionaire and his lost fortune. Note the line, "AN OASIS IN THE SAHARA."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EXCLUSIVE TO THIS THEATRE.
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MYSTERY,
AND
OF LOVE,
THRILLS,
ADVENTURE
SEE
REYNOLDS NEWSPAPER FOR BIG CASH PRIZE
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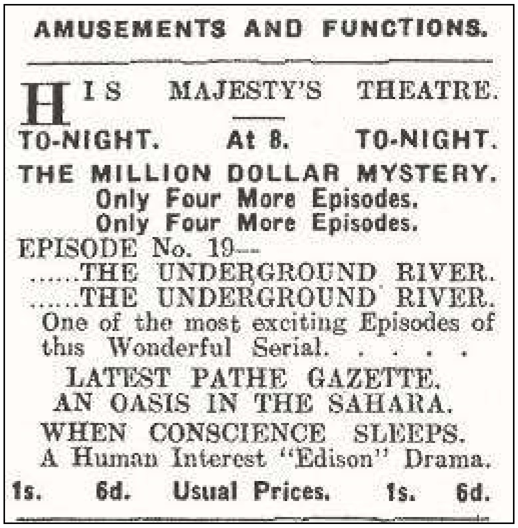

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Ashburton Guardian, September 16, 1916

Fish

We noted the Algerian fish story in passing, but it perhaps it deserves closer scrutiny. As discussed in Chapter 47, Wrecks of Ancient Life, fish are indeed found in the earth's recesses, but -- and this is not a minor detail -- only where their metabolism can be sustained by photosynthetic nutrients.

In the chapters ahead dealing with American fish tales, exaggerated as some may be, most are set in regions of karst caves where aquatic life can be verified within the entrances. Most of the artesian sites of this chapter, on the other hand, are distant from any open water and we must remain skeptical of veracity.

This is not to imply that cave fish can't exist in deserts. Phreatichthys andruzzii and Garra barreimiae are native to Somalia in eastern Africa and Oman on the southeastern Arabian peninsula, but both cases involve caves, not deep wells.

According "Fish in the Depths of the Earth," New York Times, August 6, 1865, however.

> *M. Desor, the eminent Swill naturalist, who has recently returned from an exploration to the northern Sahara... states in a recent letter that he found fish in the stream leading from of one of the wells at the oasis Ain-Tala where fish were observed when the water first rose to the surface... The most curious thing is that these fish, although coming from the interior of the earth, from a depth of more than 150 feet, having nothing sickly or misshapen about them... Beside these artificial wells, there are ponds in several oases, especially that of Urlana, fed by rich sources... These ponds harbor the same little Cyprinodonts which rise in the water of the artesian wells, by witch I conclude that a subterranean connection exists between the ponds and the wells. Probably they visit those ponds periodically, perhaps to spawn; this would explain their eyes, and their formation in general, shows nothing abnormal.*

Some accounts indicated that the Sub-Saharan fish are blind.

> *They brought out with them a quantity of fish, which swarmed round the craft, and which were found to be blind.* -- "An Underground Lake," New York Times, July 27, 1879

How did these fish get down beneath the Sahara? That they have been imprisoned there for a very long time -- for many thousands perhaps millions of years -- is indicated by the fact that they are nearly all blind. -- "Find Evidences of Ocean Life Below Surface of the Sahara," Washington Post, June 15, 1924

Others reported the opposite. "Fishes of Sahara Survive from Pre-Desert Period," New York Times, June 8, 1924, cites Dr. E.W. Gudger of the American Museum of Natural History,

> *It might be supposed that fish drawn up in this way from underground bodies of water would be blind, like those of Mammoth Cave, or otherwise especially adapted to the conditions prevailing in their habitat. But this is not the case.*

As speculated by French scientist, M. Edouard Blanc,

> *These fish are extremely hungry and reduced to the utmost degree of famine they can endure. They are generally very thin... The minute algae, small crustaceans and organic debris which might be found in waters below the surface were not enough to keep the fish alive for any considerable length of time.. They must have some way of passing to and from the surface of the ground, not only through artificial wells, but through natural connections.*

Could these artesian wells be connected to the Nile?

> *A peculiarity of the wells is that tiny little fish, resembling small whitebait, are brought up in the water. They were first noticed by General Zickel in the water spouting from the well of Ain-Tala, which is 145 feet deep. The length of these little creatures does not exceed one and a quarter inch. Their eyes are well shaped, although they emerge from regions so dark. They are malacopterygians, of the species Cyprinodon cyanocaster. Similar specimens have been found in some of the ancient wells of Egypt that were cleared by M. Ayme; as these, in all probability came from the Nile, and as the sand excavated from those wells is much the same as that of the Algerian borings, it is supposed that in both cases the fish infiltrate through with the water to the subterranean sheets.* -- "Artesian Wells and the Great Sahara," Popular Science Monthly, February 1880

> *An artesian well at Ain-Sulu, in Algeria, not only throws up an immense volume of fresh water, but also numbers of small fishes, averaging half an inch in length, and furnishing a delicate morsel for the epicure. As the sand extracted from this well is identical with that found in the bed of the Nile, it is conjectured that a subterranean connection must exist with the river.* -- Appletons' Journal of Literature, Science and Art, July 31, 1869

And what's for dinner?

> *Another curious phenomenon which the sinking of the Algerian wells has revealed is the discovery of fishes, crabs and fresh-water mollusks at considerable depths. This interesting fact has been ascertained in the artesian well called Mezer, situated on the desert of Oued*

> *Rhir, quite near one of the brackish lakes (Chott or Sobka of the Arabs) which are so numerous in the region between Biskra and Tugert. When the sounding line brought those creatures from a depth of 230 feet they were perfectly alive, and M. Just even boiled a crab, and found it of excellent taste.* -- "Wells in Sahara," New York Times, September 17, 1882

> *In the Algerian Sahara there are numerous subterranean lakes in which a number of small fish and mollusks live and multiply. Moreover, the artesian wells of the Sahara often throw out fish that are sometimes two inched in length. The governor of the oases of Thebes and Garbes, in Egypt, asserted that he took from an artesian well 440 feet deep, near his residence, fish in sufficient quantity to supply his table.* -- Scientific American, May 12, 1888

The Saharan Sea

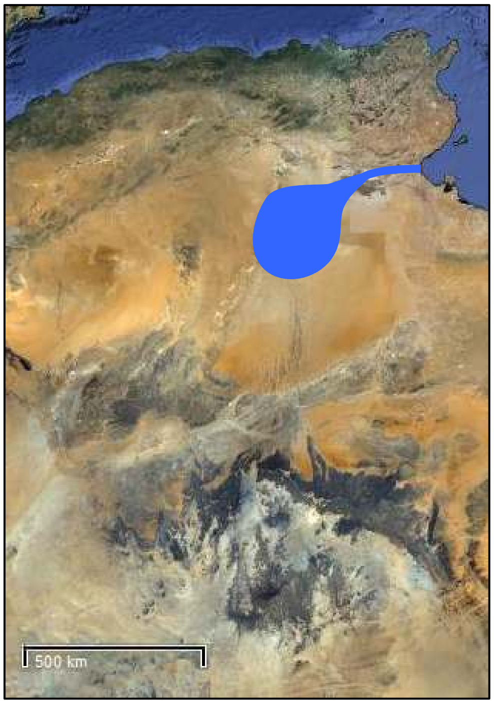
We add this section to illustrate that suppositions of Algerian waters don't have to be underground to be astonishing. Take, for example, converting the area into a great inland sea.

French designs for North Africa coincided with that nation's endeavors in Panama and the Suez. Coupled with faulty land surveying -- the 1889 Oued Rir map earlier in this chapter shows "-31" as a Chott Melrir elevation -- an ambitious French engineer discovers another cause for excavation, an inland sea that's begging to be filled.

Quoting from Handbook for Travelers in Algeria and Tunis (1891) by Robert Lambert Playfair,

> *Between a place 70 kilometers S. of Biskra and the sea, exists an immense depression, 375 kilometers long, occupied by three chotts or salt lakes, all of which are below the level of the sea. The isthmuses which separate them are of varying heights, but both considerably above the sea level. The whole of this area is separated from the sea by a third isthmus, also considerably above the Mediterranean.*

> *The quantity of water necessary to flood this depressed area would be 193 millions of cubic meters. M. Roudaire proposed to cut through the narrowest portion of the inland isthmuses, thus leaving the three basins prepared to receive the waters of the Mediterranean. He then intended to cut a canal between it and the sea, about 15 kilometers N. of Gabes, at a place where the work would be facilitated by the presence of another small chott, and by the depression through which the Oued el-Melah flows into the sea.*



The illustrated inland sea is geographically conceptual, at best, as Capt. (at the time) Roudaire was operating under topographical delusion. American news accounts of the proposition took their liberties, suggesting in some cases that the sea might be a million square miles, somewhat larger than the modern Algerian nation.

"Fishes of Sahara Survive from Pre-Desert Period," New York Times, June 8, 1924, even provides the sea's historical background.

> *Another project, more recently discussed, has been cutting of a channel in the coast of the Gulf or Gabes, in Eastern Tunis, thus letting the waters of the Mediterranean into a vast tract of desert south of the Atlas Mountains. According to L.M. Phillips, whose In the Desert was published a few years ago, the voyage of the Argonauts, in Grecian legend, must have been*

> *into a sea which occupied this region. Shells, marks of erosion and old shore lines are said to prove the existence of this body of water.*

Ensuing discussion was protracted and by no means definitive, but in light of environmental awareness, looks like a prelude to concerns that would rarely surface for yet another century. We'll cite a few reactions.

From the Christian Union, September 3, 1879,

> *The latest advices from Paris indicate that the conversion of the Desert of Sahara, in order to flood a vast depression that has been discovered, and return it into an inland sea might not be so much a blessing to the Continent of Africa as was claimed when the project was first broached. Its shores would be as arid as those of the Mediterranean at Tripoli, and if the climate should change, the date crop, which is the principal support of the natives, would be ruined... It is also predicated that the pressure of the mass of water would produce perturbations in the subterranean currents which feed the artesian wells in the oases, and might cause them to fail.*

From the New York Times, July 15, 1883,

> *Speaking of the proposed Saharan Sea, Dr. Bodichon, of Algiers, in a pamphlet just published, deprecates the formation of a vast inland salt water lake till we find out to a certainty whether the salt water thus introduced may not penetrate to the fresh water sources penetrating underground and deprive us of the means of obtaining artesian wells."*

Again from the New York Times, this one from June 20, 1886,

> *A few weeks ago M. de Lesseps was again advocating the plan for making lakes in the Algerian Desert. Very little has been said about this enterprise since Commander Landas went to the African coast a year ago to select the site of a new harbor and to sink artesian wells for the use of workmen. The old canal builder has a great task on his hands in the New World, and it may be that he is unwilling that the money of French investors shall be diverted at this critical time from the work on the Panama Isthmus to any other similar undertaking.*
>
> *The African project was broached by Col. Roudaire, and a curious misunderstanding about its features has given rise to many absurd speculations as to the probable effect of its successful completion. Civil engineers have declared that the creation of a great inland sea in the place of the desert of Sahara might lower the temperature of Europe and cause a most formidable current in the Straits of Gibraltar. Upon the assumption that this sea would cover 1,000,000 square miles it has even been said that the withdrawal of so great a body of water from the ocean would lessen the depth of water in the world's great harbors.*
>
> *But the surface of the desert does not lie below the level of the sea. Its average elevation above that level is said to be at least 1,000 feet. Dr. Lenz explored a large area in the western section of the desert and found no point that was not at least 400 feet above the ocean's surface... The great African desert cannot be transformed into an inland sea until water can be made to run up hill or until some great convulsion of nature shall cause its surface to sink.*
>
> *The French Commission that examined Col. Roudaire's plans never thought of drenching the Great Desert, nor did M. de Lesseps and his engineers, who visited Tunis in 1883, submit a report that recognized the possibility of making so great a change in the condition of Africa. But they were convinced that two lakes could be made near the northern coast, and that money spent in making them would be well invested... This area would be about 3,100 square miles, or less than half the area of Lake Ontario.*
>
> *The creation of new lakes in the place of these salt marshes and brackish pools would in all probability transform a large area of barren land around them into land that could be cultivated. Evaporation from this body of water would supply the aqueous vapor without which there can be no vegetation. The climate of the adjacent country would be improved. But the flooding of only 3,100 square miles would not lower the temperature of Southern Europe, nor would it deprive the world's harbors of the water required for the maintenance of ship channels.*

Needless to say, as the Mediterranean couldn't be induced to run uphill, the plans withered, but where money's to be made -- albeit in dollars or in francs -- there will be shady characters. From the New York Times of August 9, 1884,

> *A Sahara Swindling Scheme. A parallel to the Port Breton affair was tried today before a Paris court. Two enterprising gentlemen, M. Menier, who seems to be a journalist, and M. Allemand, described as a banker, conceived some time ago the ingenious idea of turning the dry but fertile soil of the Sahara to profitable uses. This was to be done by means of artesian wells and artificial oases. The capital to be subscribed was 400,000f., half of which was to be handed over to the founders in return for the idea and for lands which had been purchased from Arab chiefs. In order to stimulate the co-operation of capitalists two newspapers were founded, the France Populaire, at Paris, and the Sahara, in Africa. The judicial authorities had their attention called to this strange enterprise, and came to the conclusion that MM. Menier and Allemand were swindling the investors who had been inveigled into the business. Allemand at once took flight, and Menier, who was tried today, was condemned to two years imprisonment and a fine of 1,000f.*

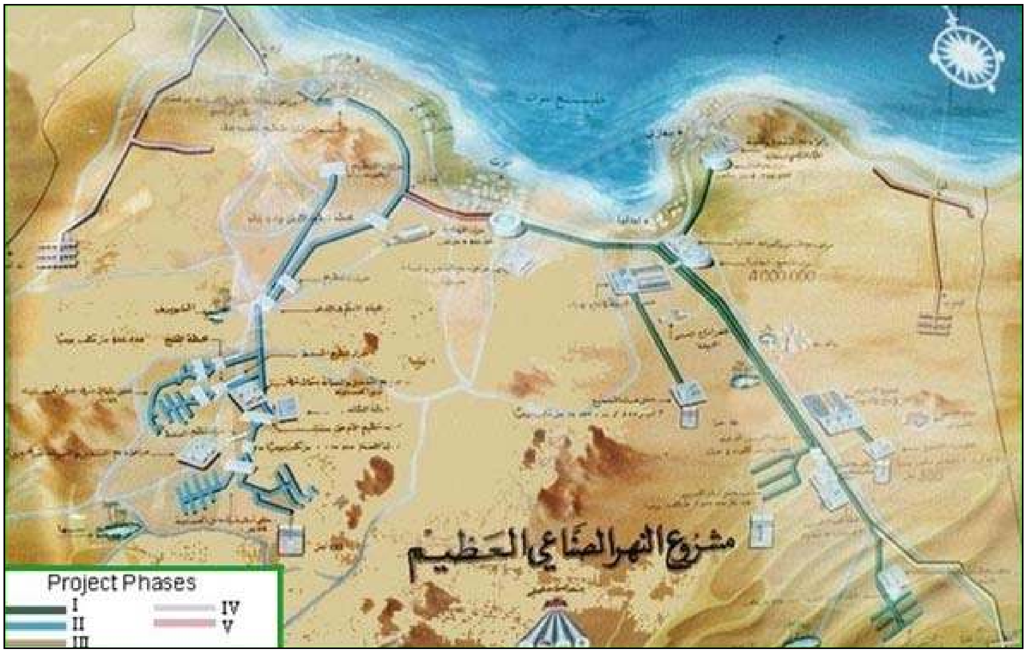
Might it be that the Saharan Sea is more westerly? "The Phantom Islands," Life, December 6, 1948, quotes an adventurer of 12 years earlier.

> *Our stores were rather low so I decided to return to Port Etienne and replenish them before resuming the voyage to Dakar. At Port Etienne I revisited the Foreign Legion officer, whose acquaintance I had made on a previous visit, and told him of our strange experience. He said that the rising and sinking sand islands are well known in that part of Africa. The natives call them the Phantom Islands. The officer said that French scientists attribute the islands to a great river that flows under the Sahara Desert and empties somewhere on the floor of the Atlantic, 60 to 100 miles from the coast. The scientists believe that sand gathers in the outlet of this underground river and, at intervals, the sand clogs the outlet completely. Then the dammed river, increasing its pressure, finally succeeds in belching the tremendous harrier of sand into the ocean. These sudden upheavals of sand from islands that rise to the surface, later settling and sinking below again.*

But in search of a sea below the sands, perhaps we've wandered too far westward. Let's turn to Libya.

The Great Man-Made River

Exploring the Sahara for oilfields in the 1950s, geophysicists found not only petroleum, but also 35,000 cubic kilometers of fresh water underlying the arid landscape. Libya began construction of the Great Man-Made River (GMR) in 1983 to funnel this resource to the populated coastline.



Col. Muammar al Qadhafi deemed the GMR to be the showpiece of the Libyan revolution. "Libya Launches $25 Billion Project to Quench Sahara Nation's Thirst," a feature of the October 3, 1985, Wall Street Journal, began.

> *Unofficially, it's called The Great Madman River by cynics who consider it just another wild venture by Libyan strongman Muammar Qadhafi.*

Contractor for the job, however, was the American firm Halliburton and unlike earlier proposals for Algeria, the Libyan system was aimed downhill.

"The Thirsty Lift a Glass to a River and Qaddafi," New York Times, October 31, 1998, brings us somewhat up to date.

> *It is not that there have not been any problems. Ever since the water began to flow in September 1996, Tripoli's old water mains have burst, one after another, unable to withstand the pressure of water that tumbles into the capital's colonial-era water system from a storage tank here in Sidi Saye, which is about 400 feet above sea level.*
>
> *On countless occasions, local residents say, the flooding has transformed parts of the capital into lakes, with geysers spewing water into the air from corroded Italian-made iron pipes. And though the Tripoli branch of the project is supposed to carry 660 million gallons of water a day, the amount flowing now is still a relative trickle.*
>
> *Still, Libyan engineers said in interviews here that 87 percent of the work on the Tripoli section had now been finished, and they expressed confidence that all of the work would be completed in early 2000.*

> *In a country without a single free-flowing river of its own, water flowing at full stream through the pipe, more than 12 feet in diameter, would be enough to irrigate vast new agricultural projects.*
>
> *In the Tripoli section, among the work that remains unfinished is a section of the pipeline that is supposed to end at Tarhuna, about 40 miles southeast of Tripoli, where American officials have said Libya has been building what would be the world's largest underground chemical weapons plant in a hollowed-out mountain.*
>
> *"This project is just to carry water," declared Adel Bakir, the manager of the Tripoli section of the enterprise.*

Phase I of the GMMR, price tag, $5.5 billion, has transported 2,000,000 cubic meters/day since 1991 to the coastal strip between Sirte and Benghazi, 1200 kilometers north.

Phase II, at just over $8 billion, carries 2,500,000 cubic meters/day to the cities between Sirte and Tripoli, Libya's capital, which received its first GMMR water in September 1996.

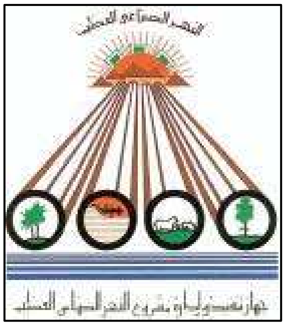
Phase III, estimated to cost $6 billion, connects the two existing networks. Total production comes to 6,430,000 cubic meters/day from 1,149 production wells, most of them more than 500 meters deep.

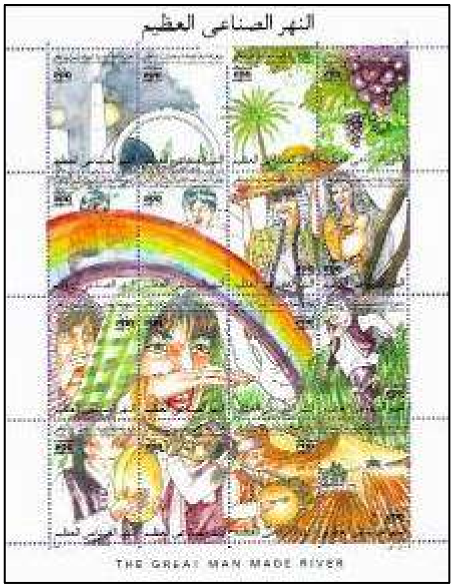
The cost of GMMR tap water is 28 cents/cubic meter, compared to desalinated water at 85 cents. Adding the cost of pumping inland, the later would be between $2.50 and $3.00/cubic meter.

Seventy percent of GMMR water goes to agriculture, with another 28 percent for municipal use and the remaining 2 percent for industry.

Qadhafi shut the subterrenean spigot to Tripoli after he fled to Hasouna, 650 kilometers to the south, but it did him little good.

We could have included the GMR in Chapter 68, a chapter about dangers, by virtue of its weapons-of-mass-destruction plant potential, but we're pretty sure it's just carrying water.


النهر الصناعي العظيم
جهاز تنفيذ وإدارة مشروع النهر الصناعي العظيم

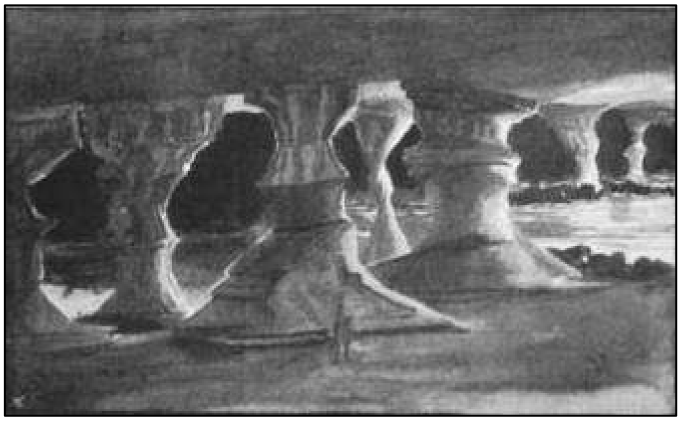

النهر الصناعي العظيم
THE GREAT MAN MADE RIVER

Thus we end our Saharan safari, one in which the waters are indeed underground, but perhaps not exactly riverine.

"Queer Story from Africa"

As we're nearby, however, we'll slip over to the Horn to note how journalism can flavor an explorer's account. The February 17, 1895, Salt Lake Tribune reported a "Queer Story from Africa. Discoveries Made by Donaldson Smith's Party."

> *The Associated Press has received the following letter from Dr. A. Donaldson Smith of Philadelphia, in which the news of the Lake Rudolph East Africa Expedition is given up to December 14, 1894. The letter is dated from the Shebeyll River near Somall Land.*
>
> *A Subterranean Passage*



> *"A large tributary of the river Juba had carved a way for itself under a mountain a mile in length. On the other side of the stream were great vaulted chambers from 125 to 150 feet high, and supported on massive columns. The columns were most ornamentally carved by the waters, and many would form long arched passages. The mountain was hollowed out a great distance on the other side of the stream, which I have named the 'Cave of Windlawn.'"*

Written for the popular press, the piece portrays a picture somewhat different than that in which the author reported his findings to his peers. From Smith's "Expedition through Somaliland to Lake Rudolf," Geographical Journal, August 1896,

> *I shall not tire you with details, but before we get back to Somaliland I must mention some wonderful caves we discovered. Hearing that they were some 30 miles to the south of Ginea, Mr. Gillett and I avoided the Abyssinians for a few days on the excuse of elephant hunting, and visited them. We were thunderstruck when we discovered what a superb underground palace the River Web had carved for itself as it dashed through a mountain of quartz. It seemed as if Nature had confined herself to human ideas of the grand and the beautiful in this work, so regular and ornate were her designs. Passing columns and arches and altars of apparently the whitest marble, the clear water disappeared into the dark recesses of a pillared temple. I can give you no idea of how ornate the columns were, with their beautiful capitals and splendid bases, or of the magnitude of the subterranean chambers.*

For the public, we've a river flowing through a great African mountain, a stream we envision the torch-bearing explorer traversing by boat. For the scientific readership, on the other hand, it's a splendid cavern of geologic note, but not an active watercourse.

The latter is the truth. The River Jubba ("Webi" is Somali for river, thus the report's "Web" confusion) is very much above ground, that is, when it flows at all. Wyndlawn Cavern (not "Windlawn," a newspaper's error) indeed exists, but transmits no river.

And now to a land even more distant.

Shambhala

The mythical Kingdom of Shambhala predates Tibetan Buddhist, with which it is now generally associated. As noted by the 14th Dalai Lama in 1985, Shambhala is not an ordinary country.

> *Although those with special affiliation may actually be able to go there through their karmic connection, nevertheless it is not a physical place that we can actually find. We can only say that it is a pure land, a pure land in the human realm. And unless one has the merit and the actual karmic association, one cannot actually arrive there.*

Nicholas Roerich's "Song of Shambhala: Thang-La" (1943)

The myth of Shambhala -- a land of enlightenment and longevity -- was central to the Theosophical Society in the latter 1800s and was the basis for the Shangri-La of James Hilton's Lost Horizon (1933).

As with ancient tales of all traditions, however, concepts alter, weave and morph. Thus the Shambhala celebrated by the modern Western occult movement merges with another kingdom, the ominous hollow-earth realm of Aghartha.

The Hindu Vedas speaks of the sacred River Sarasvati, "saras" meaning "pool or water body" and "-vant," a suffix for "having many pools." The Vedas suggest that the Sarasvati originated in the high Himalayas where she "burst with her strong waves the ridges of the hills" and describes the river as flowing to the samudra, usually translated as ocean, as "samudra" means "with waves."

The Sarasvati was said to flow by subterranean channel, joining the Milky Way and the Ganges at Benares -- or Prayag (Allahabad), depending on the source -- as an intersection of waters from three worlds.

Whatever there may have been, however, has long since dried up and isn't the present-day Sarasvati, which originates in the submontane Ambala district and joins the Ghaggar near Shatrana.

But just as we're relegating another underground river to the folk-tale file, we're informed that the modern Ganges has its own subterranean characteristics. From "Fraser's Journey through the Himalaya Mountains," Edinburgh Magazine, September 1820,

> *This mountain, which is considered to be the loftiest and greatest of the snowy range in this quarter, and probably yields to none in the whole Himalaya, obtains the name of Roodroo Himalaya, and is held to be the throne or residence of Mahadeo himself. It is also indiscriminately called Pauch Purbut, from its five peaks... These form a sort of semicircular hollow of very considerable extent, filled with eternal snow, from the gradual dissolution of the lower parts of which the principal part of the stream is generated.*

> *About thirty miles west from Bhagirathi* [We'll standardize the spelling in this section] *Uttarakhand, is Gangoutri, a village near the head of the Bhagirathi, considered the main and proper head of the Ganges. A few miles above, it is seen flowing with a moderate current, fifteen or twenty yards broad, and about waist-deep. Higher up, it flows beneath beds of snow, so deep that even its sound is not heard. At length is perceived a wall of rock, from an angle of which, called by the Hindus the Cow's Mouth, on account of its rude resemblance to that orifice, issues the Ganges.*

As Gaumukh (cow's mouth) Cave lies at the base of a 40-kilometer glacier, the outflow is of little mystery, but we're looking at the lore, not the hydrologic science. For some distance the river is called the Bhagirathi, but then becomes the Ganges.

G.T. Vigne, who traveled in Kashmir and Ladakh in the 1830's described how the Bhagirathi dips underground and then resurfaces.

> *The Bhagirathi River, after flowing for some distance under the bank, suddenly disappears beneath the ground. It first loses a portion of its water in numerous little whirlpools, that are seen in full play amongst the rounded stones in its bed; and all that escapes absorption in that place pursues its course for a little farther, where it suddenly disappears through the bottom of a large fissure, formed by the almost perpendicular position of the limestone strata, and nearly large enough to allow a man on horseback to sit upright in it. The natives say that the spring of Achibul, or Yechibul, is but the reappearance of the River Bhagirathi. Probability is strongly in favor of this theory. Walnut-shells that have been thrown in the Bhagirathi are said to have reappeared at Achibul; and the direction thus ascribed to the river is much the same, as it would have followed on the surface.*

Walnut shells carried to Achibul poses a problem as Achibul lies in Kashmir to the west, while the Bhagirathi drains to the east as the Ganges, but India is a mysterious land.

As evidenced by the 1888 Encyclopedia Britannica, Ganges whirlpools have attracted the attention of geographers from the early 19th century.

> *The Brahmaputra is navigable as far as Dibrugarh, but in the dry season only for steamers of light draught. In the rains it overflows its banks and spreads over the country for hundreds of square miles. At Godlanda, where it joins the Ganges, the current is so strong during the rains, and the eddies and whirlpools formed by the meeting of the waters so numerous, that large and powerful river steamers are often unable to make headway, and have to lie for days until the river subsides.*

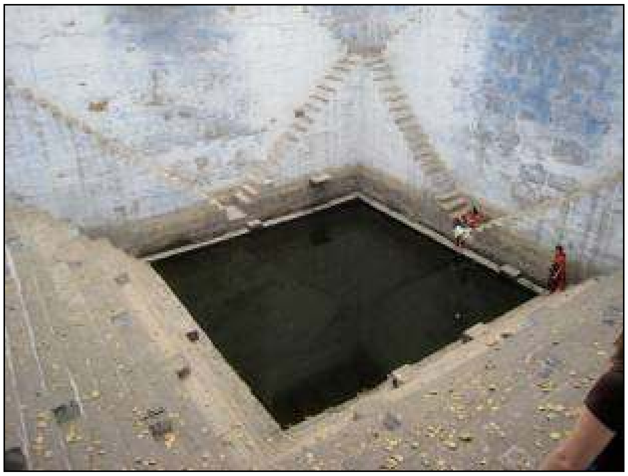
To where do such whirlpools whirl?

> To the intersection of the Serasvati, the Ganges and the Milky Way?
>
> To Aghartha?

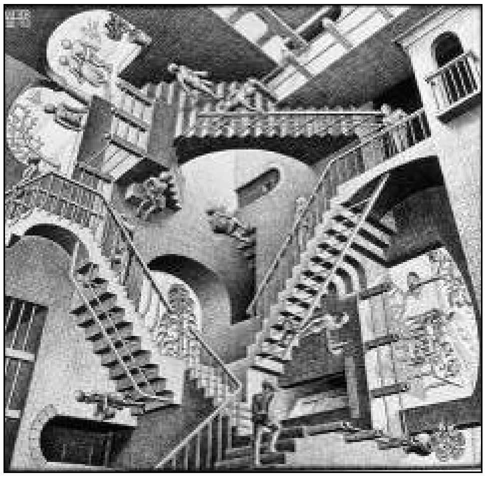
C.H. Tawney's translation of the eleventh-century Somadeva's Katha Sarit Sagara (Ocean of Streams of Story) contains the following reference to the Naga underworld Patala, the dimension of hell where wicked souls committing grave sins are punished.

> *I perceive those who have written the books and gave information are mostly foreigners and they do not know about this correctly. I suppose the underground dimensions of the Nagas contains priceless diamonds, rubies, etc. This is under the control of Lord Shiva and anyone with intense devotion towards Lord Shiva could enter this portal. But a person devoid of devotion towards the Gods could never make it out if he goes in.*

The well of Patanjali in Sheshna, Benares, India, traditionally where the Yoga Aphorisms of Patanjali was written and said to be the entrance to this underworld, is shown below, along with the remarkable-similar well-known Escher etching.



Well of Patanjali



M.C. Escher's "Relativity"

We depart distant India without diving into the eutrophic pool, but better understanding how ageless tales indeed remain ageless.

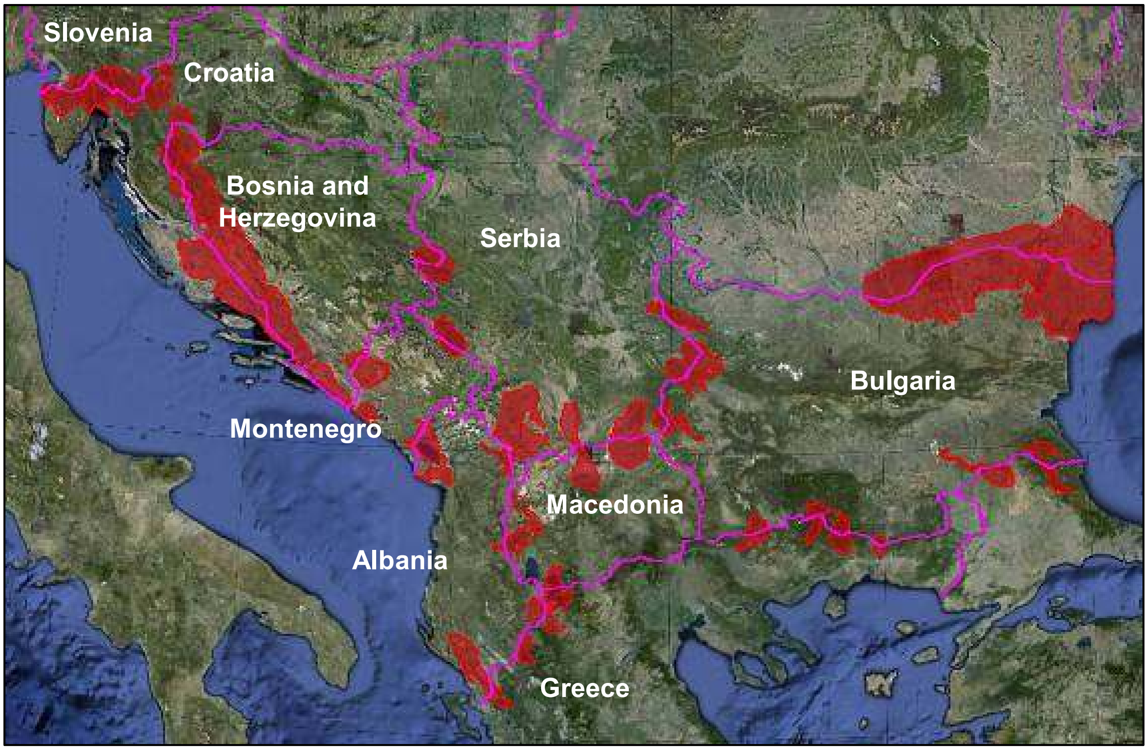
Ageless, that is, in that those of us who remember Three Dog Night's lyric, “How does your light shine on the road to Chamballah.” should by no means be considered aged.

CHAPTER 72
UNDERGROUND AND BALKANIZED

To "balkanize" is to divide into small factions or fragments, term was first used in the 1920s in reference to the political consequence of the dissolution of the Ottoman Empire into small European nations.

In this chapter we will explore the Balkan Peninsula in light of karst piece-wise karst conduits, threads stitched up and down across the map.

The map shows shared karst aquifers, and thus zones of underground transboundary streamflow. Not shown are alluvial aquifers and karst aquifers entirely within a single nation.

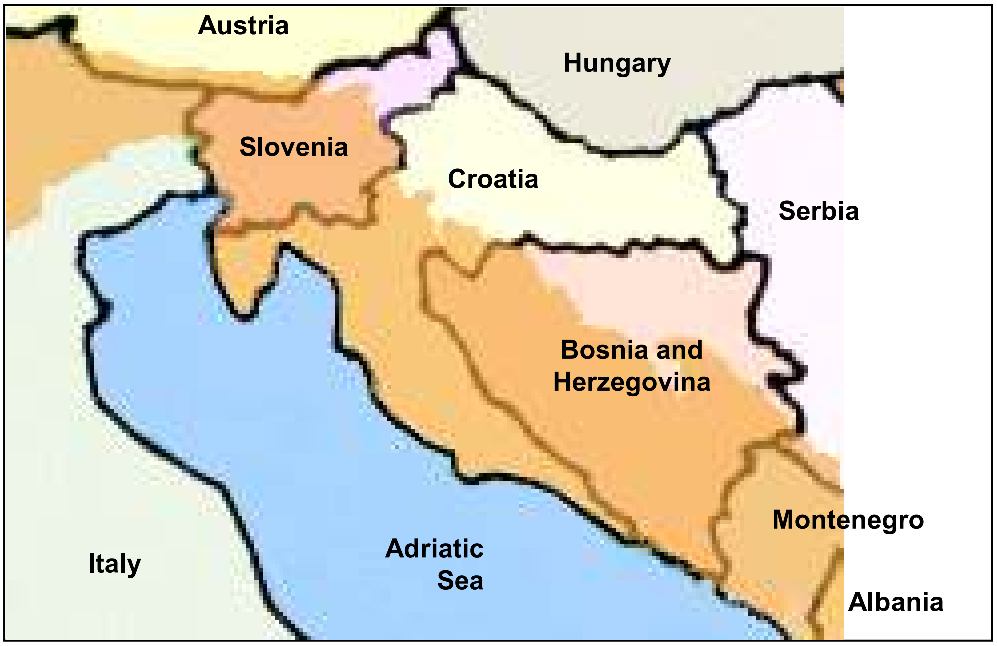

Slovenia
Croatia
Bosnia and Herzegovina
Serbia
Bulgaria
Montenegro
Macedonia
Albania
Greece

Below are border lengths spanning karst aquifers.

Kilometers of Common Karst Aquifer	Albania	B & H	Bulgaria	Croatia	Greece	Macedonia	Montenegro	Serbia	Slovenia
Albania									
Bosnia & Herzegovina									
Bulgaria									
Croatia		496							
Greece	109		32						
Macedonia	75								
Montenegro	35	90							
Serbia	30	117				65			
Slovenia				148					

As such karst formations are rife with subterranean channels, what we have above are nearly 10,000 kilometers of transboundary waterways between nations that may or may not be feuding or further subdividing.

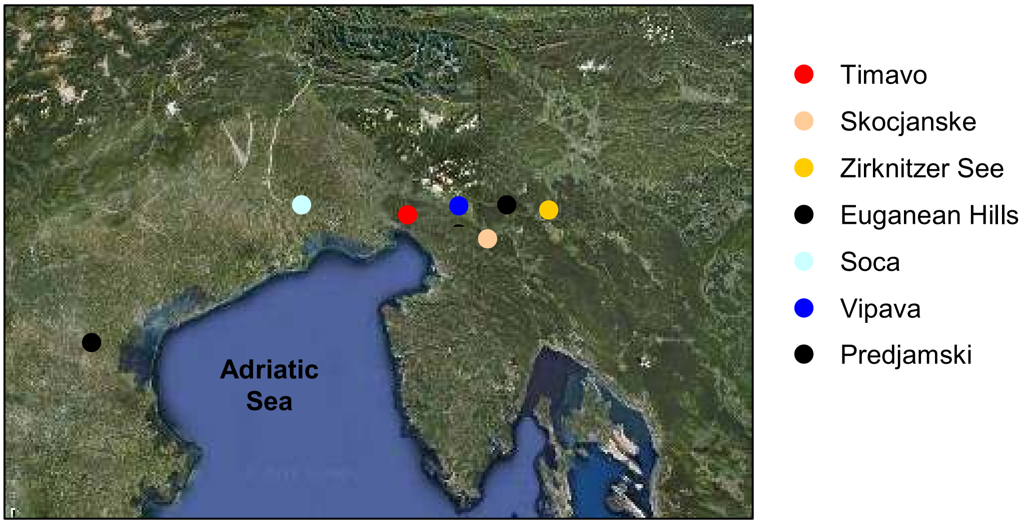
Italy, Romania and Turkey are located mostly outside the geographic peninsula, but share some portions of underlying karst with Balkan neighbors and thus are considered Balkan in a geologic sense. The map below shows the Dinaric karst belt wrapping from Italy and Austria in the north-west 700 kilometers to northern Albania in the south-east, the largest single karst expanse in Europe.



With that brief overview -- given the region's political turmoil, it's wise to regularly review what country's what -- we will look at three Balkan river systems noted for fluvial disappearances and reappearances, sometimes not even in the same country.

The River Timavo

As with several chapters in our journey, a map's useful for relating rivers speculated to dive down in one place and pop back up in another.



The Italian River Timavo flows from springs 2 kilometers inland to Duino at the head or the Adriatic.

Springs of Timavo

Modern Duino Harbor

The hydro/historical question: What feeds the Springs of Timavo?

The Ancients were amazed that such a short river could be of the Timavo's width and depth and were astounded by the river's flood flows. "According to John Conington in P. Vergili Maronis Opera: The first Six Books of the Aeneid (1863),

> *"Fontem Timavi" is rightly explained by Henry of the fountain or source of the Timavus. Between this and the sea (a distance of about a mile) there are subterranean communications, through which the salt water forces its way, breaking out at the fountain through seven mouths or boles in the limestone rock, and overflowing the channel of the river.*

This theory -- that sea water pushes its way back to the springs -- might fit into Chapter 8, Subterranean Engines, but most speculation more astutely looked inland. From Chapter 3, Roman Encyclopedists,

> Strabo's mention of the disappearance of the River Timavus in a cavern east of Trieste and its reappearance at the coast.

> Pliny's mention of a river that goes underground as "does the Timavus in the district of Aquilea."

> Virgil's description,

> *Fontem superare Timavi*
> *Unde per ora novem vasto cum murmure mentis*
> *It mare preruptum, et pelago premit arva sonanti.*
>
> *The spring of the Timavo,*
> *From which through the nine mouths with a mighty roaring of the mountain*
> *The sea goes rushing forth and presses the fields with its resounding flood.*

As noted by Elisee Reclus in The Earth: A Descriptive History of the Phenomena of the Life of the Globe (1872), however,

> [Virgil's count] *no longer applies to the mouths; at present they do not reach the number of nine, because either the extermination of the woods of the Carso has diminished the mass of the water, or the action of the stream and the alluvium of the delta have modified the form of the shore.*

In short, River Timavo, where do you come from? Where do you go?

The Timavo, it was agreed my most, was fed by a mighty underground channel. Many sources were proposed, six of which we'll review.

1. The Danube

We can dismiss that the Timav is a subterranean offshoot of the Danube by tracing the idea to an erroneous interpretation of Argo's downriver journey to the Adriatic.

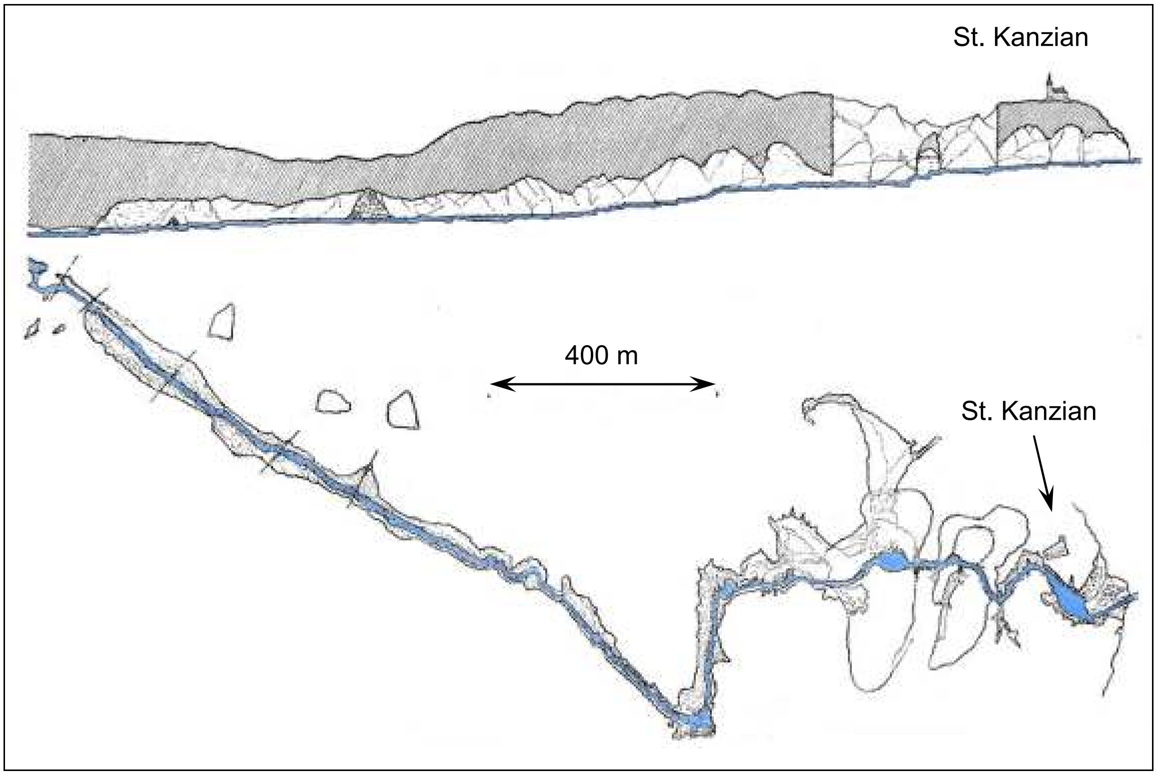
2. The River Reka

As "reka" is Serbo-Croatian for "river," the "River Reka" is a bilingual pleonasm, but that's its usage in English-language geographic references. The linguistic duplicity is akin to the "Rio Grande River."

The Reka drains 442 square kilometers of southwestern Slovenia into a highly-incised canyon flowing in a torrential regime into Skocjanske Cave, surely Strabo's "cavern east of Triste." Discharge into the cave mouth averages 8 cubic meters/second. Discharge in times of drought drops below 1 cubic meters/second and in extremely high water situation it can exceed 400.

Within the cave, the Reka can be navigated for 2.4 kilometers to an inverted siphon. Tourists can explore by foot, but only researchers can travel by boat.

Skocjanske
€14.00



Map of the underground River Reka at Skocjanske Cave, 1905.

The excerpt from the March 20, 1885, Taranaki Herald gives an account of a Skocjanske visit in the days of less-restricted tourism.

> *The exploring party started in two boats, along a channel about 70 yards in length, and bounded by rocky walls more than 100 yards high; then a large cave was reached, where the party lauded and fastened the boats, as waterfalls and rapids prevented their further use. The underground journey was continued on the rocky banks, the river being crossed several times on ladders. Six waterfalls were passed and a seventh was reached. The whole distance traversed was not more than 300 yards, and those who took part in it were sorry that they could do no more.*

But where did the Reka then go?

Pietro Imperati (1550-1631) claimed to have proven the continuity of the Rivers Reka and Timavo. From his correspondence to the naturalist Ulisse Aldrovandi,

> *More and more times I went to observe river Timavo to know more about it. You know well that ancient people said the river had seven or nine mouths. I counted more than eighteen of these mouths and certainly there are more. Part of these gush with enormous whirls, others with countless ebullitions.*
>
> *We know the course of the swallowed river till the mouth through three experiments; at first with a dry seaweed, than with the leaves of a type of foreign plant and above all of pine-tree and cypress. At third with broken leaves of grain. But there's more to know about it and about the spring of waters. The mouths, in fact, are larger than springs.*

What isn't clear is where in the river's route Imperati input his tracers. Physical proof of the Reka-Timavo connection would require beginning above Skocjanske Cave, but the reality is that vegetative matter introduced at that point would be impossible to discern by the time it reached the Timavo.

Three centuries later, the Austrians were out to solve the mystery by explortion. From "A Subterranean River," Scientific American, February 14, 1885.

> *Members of the* [Austro-German Alpine Club] *determined, some time ago, to institute a systematic second exploration: of the subterranean course of the river Reka. Rising in the Schneeberg, in Carniola, this mysterious stream suddenly disappears in the so called Karst caverns. At San Giovanni di Duino, twenty miles distant from the spot where the Reka is lost, a river of corresponding magnitude is found issuing from the foot of a hill. This stream is known as the Timavo which takes a westward course, and discharges its waters into the Bay of Montalcone. As to the identity the identity of the Timavo with the Reka, there cannot be a doubt.*
>
> *The expedition, consisting of four persons in two boats, proceeded on their eventful voyage... The river flows for 200 feet through a narrow channel between two perpendicular walls of rock, estimated to be upward of 100 yards in height. At the end of this channel the explorers, whose course throughout was illuminated by the magnesium light, found themselves in a vast cavern where they were able to land. Fastening up their boats, they proceeded for some distance on foot past several cascades and rapids... At length they reached a spot where the river contracts to a width of barely twelve feet... The advance now became more difficult, the explorers being only able to get forward by creeping and climbing. At length they came to the sixth waterfall, which the party was unable to pass. The river here runs between two perpendicular walls of rocks, and suddenly takes a downward leap of over 20 feet.*
>
> *With regard to the Italian Alpine Club, its committee has, during the past summer, done some good service by rendering the splendid cavern of Trebitsch, discovered by Herr Liudner forty years ago, accessible to ordinary tourist.*
>
> *The Trebitsch cavern is 300 feet high, 400 feet in width, and 1,000 feet in length. Through it flows a river, which several authorities believe to be identical with the Reka and Timavo, but the hypothesis is repudiated by many observers. The question can only be settled when the Austro-German Alpine Club shall have accomplished the interesting task it has taken in hand -- that of following the subterranean course of the river Reka from beginning to its termination.*

The Austro-German Alpine Club penetrated no further however, than thoise bvefore and the answer was still tentative 111 years later. "Timavus and the Supine at Vergil, Aen. 1.246," Classical World 89:5, May 1996, by Robert R. Dyer has this to say about the Reka's fate.

> *Exactly which rivers supplied water in the past to the Timavo is not fully resolved. The accepted source of the modern Timavo, the Recca (or Reka) rises on Mt. Dletvo north of Rijeka (Fiurne)* [near the modern Slovenian-Croatia border] *runs for five miles before disappearing underground in the Karst and then resurfacing for a while, to disappear through the celebrated gorge of Canziano, eleven miles east of Trieste.*

A Skocjanske-to-Timavo underground conduit does in fact exist, and at 40 kilometers, it's the world's longest.

No one's ever traveled it, though.

World Record

Longest Underground
River Reach
40 km

A health-related warning:

Following "Ought Private Lunatic Asylums to be Abolished?" in Westminster Review, July-December 1894, is an Adriatic travelogue from which the following is extracted.

> *Having obtained candles and a guide, we ascended the stony valley of the Rijeka and penetrated the vast underground cavern, from which that river issues. After we had been climbing for about half an hour over the huge boulders of rock which form the floor of the cavern, we arrived on the shore of an underground lake, similar to that over which visitors to*

> *the salt mines near Berchteegaden are ferried by the glare of pine torches. If Montenegro should ever become a haunt of tourists, the grotto at Rijeka with its fine stalactites and its infernal lake will make the fortune of some Montenegrin Charon. It is unfortunate that a place so beautifully situated as Rijeka should, like Antivari, be very unhealthy and malarious.*

3. The River Soca

Robert Dyer, whom we just quoted, informs us of other theories regarding the Timavo's genesis.

> *However it has been argued that in earlier days the source of the floods of the Timavo was the ancient Sontius, modern Isonzo, rising eighty-seven miles away as the Soca in the Julian Alps of Slovenia (once part of Carinthia), now entering the Gulf of Panzano through two mouths in its SW extremity, perhaps joined by the Natiso (Natisone), rising a little to the SW of the Isonzo and flowing through Forum Iulii (modern Cividale del Friuli).*

The River Soca to the west of the Timavo is an above-ground channel, but its route has altered several times in past eras.

According to Strabo, the River Aesontius, which in his times flowed past Aquileia to the Adriatic, was once part of the Natisone and Torre river system. A landslide in 585 severed the upper part of the Natisone and caused its subsequent capture by the River Bontius, which in turn lost its subterranean discharge into the Timavo. A subsequent avulsion of the now-larger Bontius returned the watercourse to the lower Natisone. In subsequent centuries the estuary of this new river -- the Soca -- migrated eastward until it captured the costal river Sdobba, through which the Soca now discharges into the Adriatic.

Hydrology can be complex enough without such mobility and we're not even mentioning the Soca's human-made diversions. Even in abbreviated version, it's a convoluted hydrologic chronology, but after all, we're in the Balkans.

Timavo flooding might thus have at times been due to an avulsion of an adjacent channel that would someday be called the Soca. Ensuing legend, however, might have confused the hydrology.

"Long ago, my lad, the Timavus plain before you was flooded 5 cubiti deep by the River Bontius."

+

"This, my boy, is the Fontem Timavi, so near the sea."

→

Generations later...

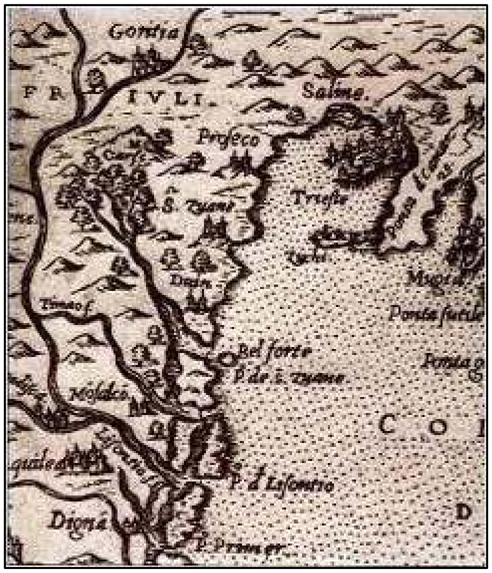
"Before our time, kids, the Soca ran underground to Timavo Springs and flooded everything 5 meters deep!"

And then, of course, there's confused geography.

In the 1571 representation of the Gulf of Trieste, the Timavo appears as a ramification of the River Isonzo, far to the west of its actual location.

In accordance with ancient writers, Carl von Czornig's L'Isonzo, il Fiume piu Recente d'Italia (1884) described a great lake in the high leg of the River Isonzo and a second great catchment in the middle leg, whose water, through subterranean channels, gives rise to the Timavo.

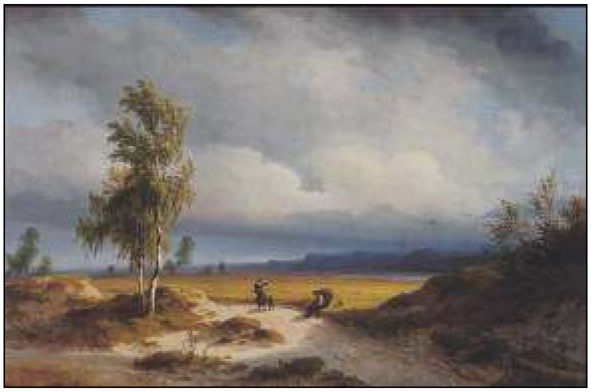
If the Timavo's location is not agreed upon, it's of little surprise that theories of its source may be literally all over the map.



4. Zirknitzer See (Lake Cerknica)

The Zirknitzer See is a Slovenian lake northeast of Trieste. While its Slovenean name is "Lake Cerknica," we'll use its German form for two reasons: its early reporting took place when the area was part of Austria, and "Cerknica" can be confused with other Balkan geographic features having proper names that look not that much different.

The Zirknitzer See can occupy 40 square kilometers in summer with a depth of 10 meters. In the autumn when rainfall is slight, the lake completely drains into the underlying karst and its bed is covered with foliage. When the rains return, the lake upwells through subterranean inlets. Sometimes the lake does not disappear for several years and in 1834-35, it remained dry for over a year. Its fish disappear and return with the water.



Zirknitzer See, Markus Pernhart (1824–1871)

View today

An early report on the lake is found in "Description of the Zirknitzer Intermittent Lake" by Georg Wernher in his De Admirandis Hungariae Aquis Hypomnemation (1551).

> *It is perhaps only less wonderful, that this* [geological phenomenon] *should be evidence for the existence in the same region of subterranean streams, which flow for great distances below ground, then come to the surface; some of them come to the surface only once, and then are visible no more. And it may also be postulated that from these hidden cavern-reservoirs, certain passages conduct these subterranean waters to the lake; especially since it be known that there are in that locality large mountain caverns, within which the roaring sound of rising or falling waters can be heard; and that the said caverns are as it were lakes, which may overflow as streams or brooks. This I believe to be possible; and testimony thereto is the fact that living ducks come swimming out on them, which nobody can believe to be possible who has ever been in subterranean places to which the atmosphere has no access. But since it is well authenticated that additions to these waters are not fed to them from the mountains by any of river-beds or other hidden water-courses, but come up by some kind of regurgitation process through fissures in the rocks, as though vomited forth, returning by the same channel to be reabsorbed, and all this at regular intervals, who will deny that there is about all this something miraculous?*

We note -- and perhaps by now have to come expect -- Wernher's reference to subterranean streams, but are astonished by the subteranean ducks.

Philip Clover described the lake briefly in Italia Antiqua (1624), confirming the ornithological note: "When the water gushes out to fill the lake there come out with it live ducks"

Johann Weikhard von Valvasor indicated he, too, had seen the same in An Extract of a Letter written to the Royal Society out of Camiola, being a Full and Accurate Description of the Wonderful Lake of Zirknitz in that Country (1687). Ducks are not included in Chapter 47, Wrecks of Ancient Life, but perhaps they should be.

Tobias Gruber's Briefe Hydrographischen und Physikalischen Inhalte aus Krain (1781) postulated an underground riverbed.

> *Below the Zirknitzer See and its surrounding mountains there flows continuous water ... All the caves and passages taken together make an underground river bed, which stretches away invisibly for so many miles, only here and there does it break into daylight a little* [as at the lake] *everywhere it collects water from above ground via abysses and finally leaves the dark regions at Oberlaybach* [Vrhnika] *and other places in the surrounding area.*

Balthazar Hacquet (1739-1815) noted that the mountains surrounding the lake, being of limestone, are filled with caves which give them a cellular structure comparable to a sponge. Even in heavy rain, no streams flow down the mountain side and only after a long delay do the springs at the foot of the hills increase in discharge. The Zirknitzer See, being a completely closed valley, begins to fill up when the underground reservoirs are full.

From American Notes and Queries, August 31, 1889,

> *Query -- How do you account for the periodical disappearance of the water of the lake of Czirknitz in Austria? -- R.B.P., Verona, Maine*
>
> *There is very little doubt that the lake of Czirknitz is simply an overflow lake fed by some subterranean river. Very probably that river is the same one which reaches the sea in that wonderful fountain of Timavus, which Virgil so beautifully describes. When the water in the underground river is abundant, the great lake fills, up; when it is low the lake disappears. It is here noteworthy that Mr. Skeat makes the "dry sea" of Chaucer (Book of Duchesse, 1028) to represent this lake.*

We didn't include Chaucer in Chapter 16, Underground Rivers in English Fiction, but it seems that we could have.

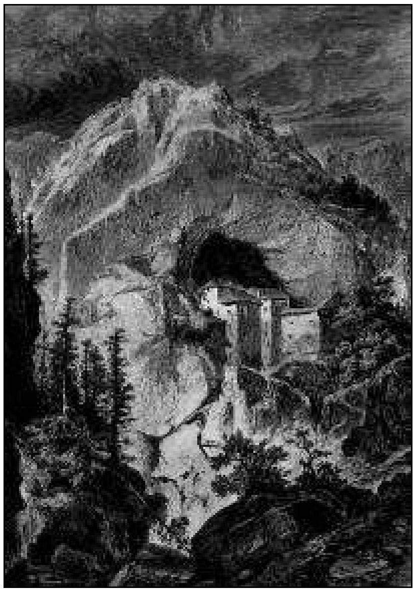
5. Predjamski Grad

In the early 1700s, Giovanni Bianchini wondered why the flow of the Timavo near Duino exceeded that of the Reka at Skocjanske Cave. Perhaps the flow was augmented from Zirknitzer See -- every time the latter dried up there was a rising of the Timavo, he'd heard -- or perhaps it was augmented from the cave under the castle Predjamski Grad, not far from Planinska Cave.

Any knight would be pleased to own a castle perched on an underground river, invulnerable from rear assault and assured of water in time of siege. Predjamski Grad is perhaps the most famous of such fortifications, nestled within a 123-meter limestone cliff.

Predjamski
Grad
€8.00

Below, a 19th-century engraving and modern photograph of Predjamski Grad.

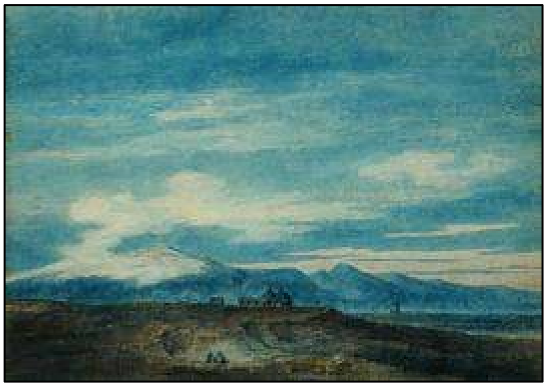


When later informed that the castle cave fed the River Lokva, which in turn joined the River Vipava, Bianchini came to doubt his Predjamski-Timavo hypothesis. He may have been onto something, however, as the Vipava is tributary to the Isonzo/Soca.

6. The Euganean Hills

Dyer also adds this possibility

> *At least by the time of the Elder Pliny and Lucan, the Romans understood that the Timavo was the continuation of a river gone underground much higher up; Lucan* [a Roman Encyclopedist, 39-65 AD] *believed that it rose in "the Euganean hill" to the west near the source of the Aponus.*



Attributing Timavo inflow to the Euganean Hills, far to the west near Venice, stretches the limits of credibility. A conduit circumnavigating the head of the Adriatic would be geologically odd and the Euganean Hills are volcanic, not karst.

We include the Euganean Hills possibility if for no other reason than to illustrate that the Romans were not unimaginative.

"The Euganean Hill from Padua" (c. 1777) by John Robert Cozens

Perhaps Lucian was referring not to the hills' actual location, but instead to their westerly direction. If so, he could have been indicating the Soca.

Modern hydrologic studies indicate that the Timavo draws from multiple subterranean channels which merge before reappearing in the springs. The springs' souflow is roughly

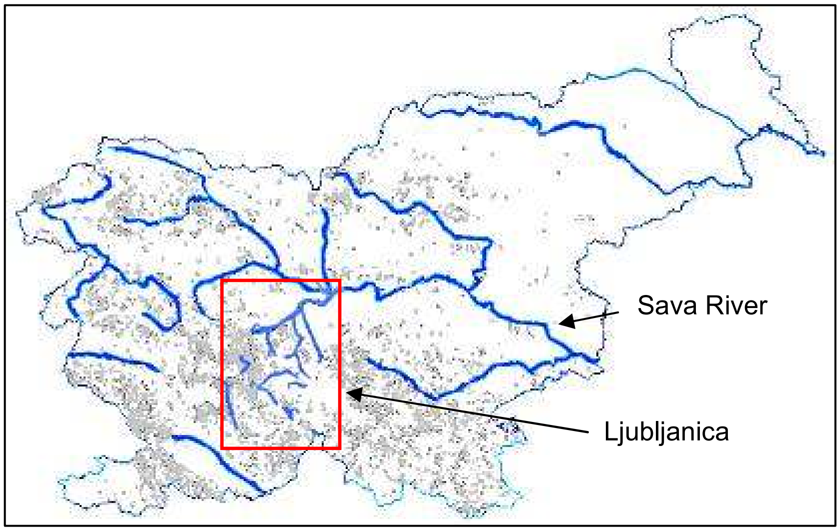
- One third from the River Reka via Skocjanske Cave.
- Two thirds from
  - The River Vipava west of Skocjanske,
  - The River Soca,
  - The River Rasa in Croatia, and
  - Infiltrated precipitation.

Lucan's Euganean Hill theory has never rises to scientific contention and the Trebitsch cavern hypothesis fails because subterranean rivers in the Trebisnjica watershed flow in a south-easterly direction, to be discussed later in this chapter. An Izoso connection, if there ever was one, is obscured by history.

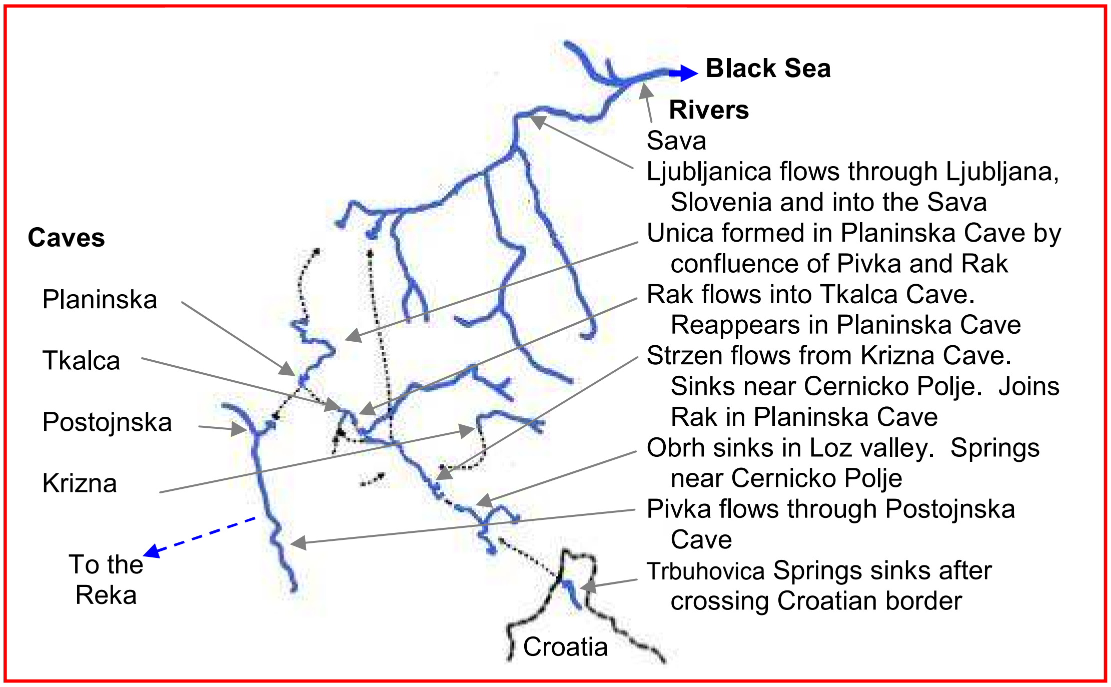
The River Timavo may be but 2 kilometers in length, but it's a civilization's worth of speculation regarding origin.

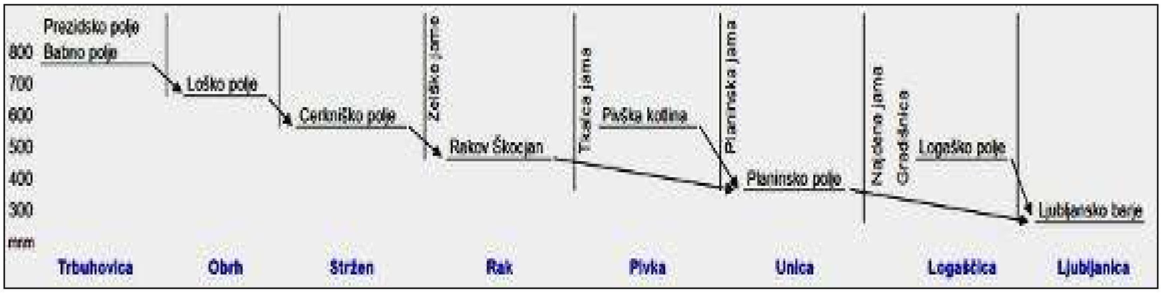
The Ljubljanica River

The River Reka's just a dip and reappearance, not that complex to map. The Ljubljanica, on the other hand, assumes seven names depending on location and cartographer. The basin extends over almost 1800 square kilometers, of which 1100 are karst. Light-grey dots signify caves.



In the cutout below, envision the Ljubljanica flow path as a watch hand sweeping clockwise from 5:00 to 1:00.


Black Sea
Rivers
Sava
Ljubljanica flows through Ljubljana, Slovenia and into the Sava
Unica formed in Planinska Cave by confluence of Pivka and Rak
Rak flows into Tkalca Cave. Reappears in Planinska Cave
Strzen flows from Krizna Cave. Sinks near Cernicko Polje. Joins Rak in Planinska Cave
Obrh sinks in Loz valley. Springs near Cernicko Polje
Pivka flows through Postojnska Cave
Trbuhovica Springs sinks after crossing Croatian border
Caves
Planinska
Tkalca
Postojnska
Krizna
To the Reka
Croatia

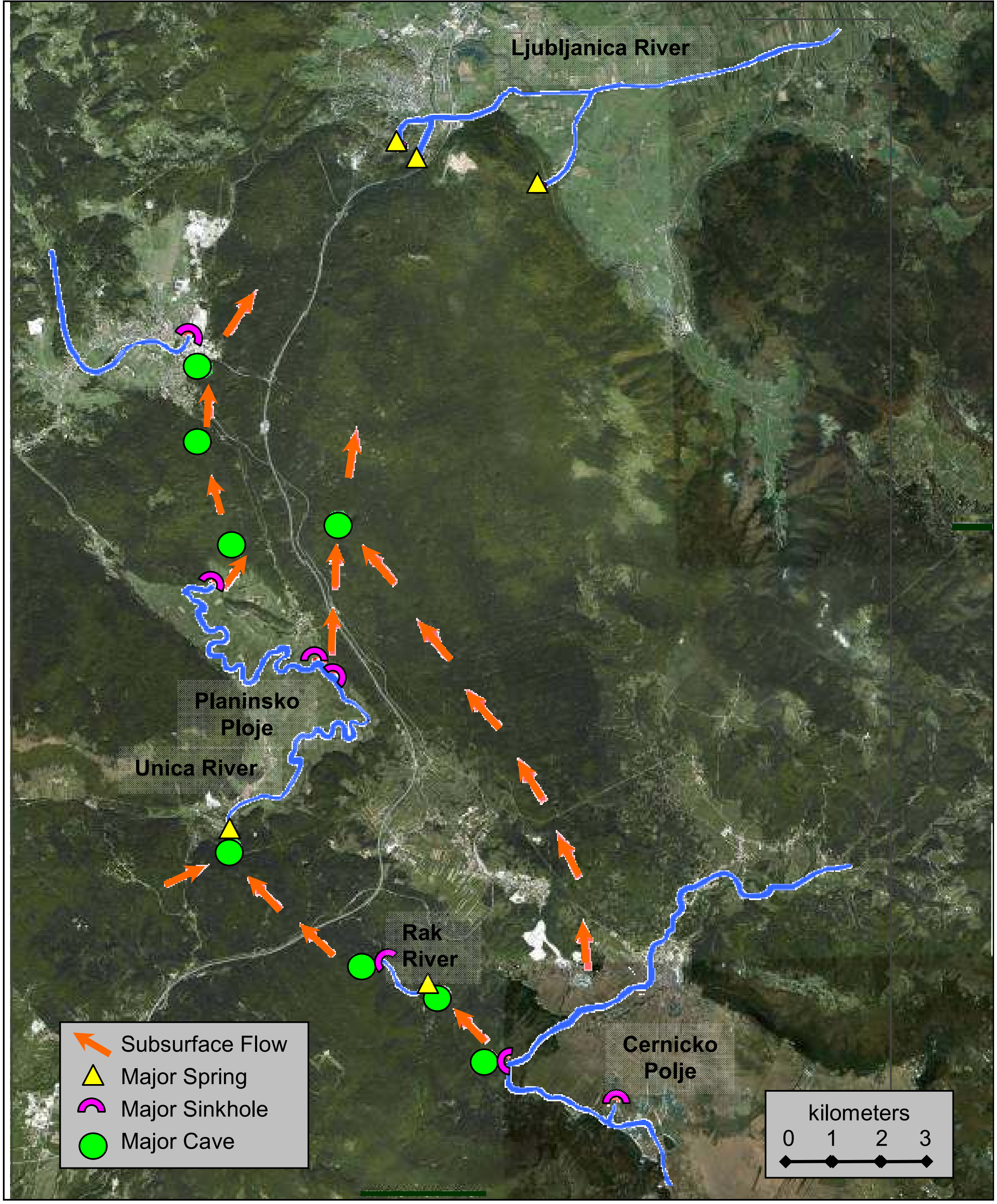

Prezidsko polje
800 Babno polje
700
600
500
400
300
mnm
Loško polje
Cerkniško polje
Zelške jame
Rakov Škocjan
Tkalca jama
Pivška kotlina
Planinska jama
Planinsko polje
Najdena jama
Gradišnica
Logaško polje
Ljubljansko barje
Trbuhovica
Obrh
Stržen
Rak
Pivka
Unica
Logaščica
Ljubljanica

The Ljubljanica is said to be half underground, but that depends upon what's said to be the Ljubljanica. Below is a pair of photos of the headwaters.

Headwaters

The magnitude of the upwellings suggests more than local riparian runoff alone. Something seems to be coming from somewhere, but without a great deal of fieldwork, there are many possible somewheres.

The map below shows a bit more of the system's hydraulic complexity.


Ljubljanica River
Planinsko Ploje
Unica River
Rak River
Cernicko Polje
Subsurface Flow
Major Spring
Major Sinkhole
Major Cave
kilometers
0 1 2 3

Mean discharge of the Trbuhovica reach that's actually called the Trbuhovica is 25 cubic meters/second at it upper end and 44 cubic meters/second at its mouth.

The Sava River, into which the Trbuhovica flows, continues onward through Croatia and Bosnia and Herzegovina and into Serbia, where it joins the Danube and then flows between Romania and Bulgaria to the Black Sea.

But even with the benefit of modern cartography and several centuries of geographic sleuthing, let us admit our confusion regarding this river of sequential names and inebriated directionality.

How much more confounding, then, would the geography have seemed to the early mapmakers whose principal sources were the Greek legends?

The heroic saga of Jason and the Argonauts, recorded by Apollonius of Rhodes in the third century BC, traversed the known world of Greek times.

The voyage involved overcoming obsticles, of course, but where possible, skirting perils, such as the dismal waterways with which we are acquainted from Chapter 1.

GREATEST ODYSSEY OF THE AGES!
FOR THE FIRST TIME ON THE SCREEN
JASON AND THE ARGONAUTS
TODD ARMSTRONG NANCY KOVACK GARY RAYMOND LAURENCE NAISMITH
COLOR

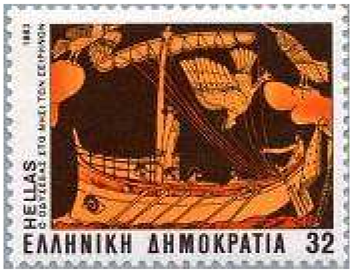
> *Thence ye must turn back a little space through the sea and beach your ship on the land of the Mariandyni lying opposite. Here is a downward path to the abode of Hades, and the headland of Acherusia stretches aloft, and eddying Acheron cleaves its way at the bottom, even through the headland, and sends its waters forth from a huge ravine.*

The Argonauts were well aware of the underworld, but as something to avoid. As far as practical sailing, on the other hand, Jason didn't hesitate when told of a remote branch the world-encircling River Ocean of Greek mythology suitable for crossing the Balkans from west to east. The River Istros [the Danube] is "broad and very deep and navigable by a merchant ship... For a long space it cuts its path as a single river through a vast territory."

Istros was said to bubble up in the western mountains, "but when it reaches the boundaries of the Thracians and the Scythians, it splits in two: one stream empties here [the mouth of the Danube]; but behind it the other branch flows through the deep gulf which rises up from the Trinakrian sea [east of Sicily] which lies along your land, if indeed it is true that the. Acheloos comes forth in your land."

For a branch of the Danube to empty into the Adriatic would be a topographic feat for an otherwise westerly-flowing watercourse, but it's what Jason was promised. He would have been unhappy to find no westerly outlet and thus had to portage the divide. Had had the brave band rowed upstream into one cave and emerged heading downstream from another, Apollonius would have surely informed us.

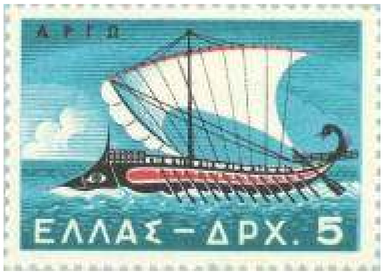
Unlike the saga of Odysseus, what we're told of Jason's boating is entirely on the surface.



Odysseus

☑Surface

☑Underground



Jason

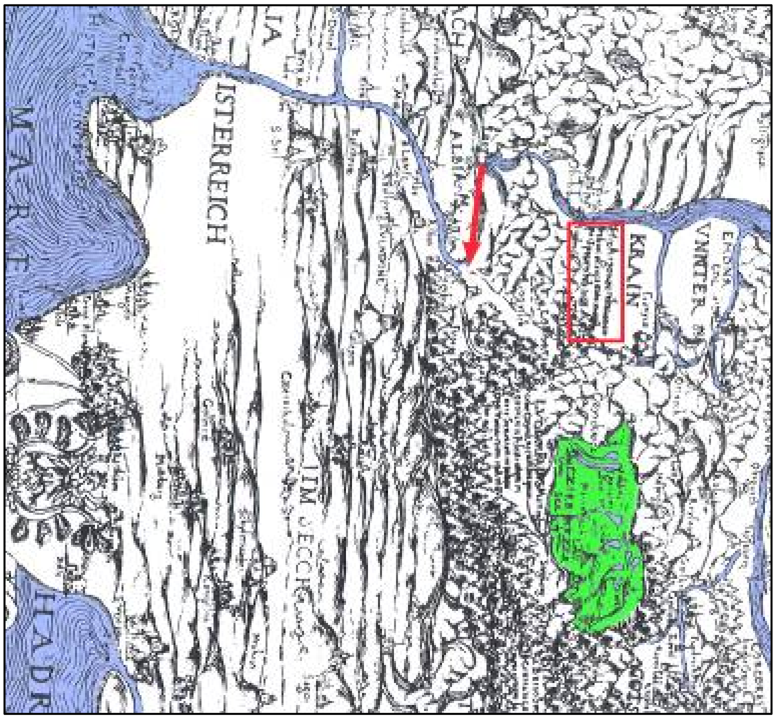
☑Surface

☐Underground

Let us now jump to the 1561 maps of the Austrian Empire by Wolfgang Lazius. To the right is a portion of one plate, rotated from the original to make north the top.

The Ljubljanica headwaters flow eastward from the upper center. The Vipava River flows westward. The modern Vipava starts closer to the Adriatic coast, but we're trying to think like Lazius.

Shown in green is Lazius's placement of the Zirknitzer See with blow and suction holes.



According to Lazius -- we've boxed his Latin in red -- this is the region is where the Argonauts dipped underground on their homeward route. We've taken the liberty to mark such a headwater-to-heeadwater shortcut with the red arrow.

But as a subterranean boat ride wasn't part of the original sage, why did Lazius include reference to a sub-mountain river on his map?

R. Trevor Shaw and G. Macqueen James address the question in "Did the Argonauts of Greek Myth Go Underground in the Slovene Karst?" in Acta Carsologica 27:1, 1998. Their conclusion:

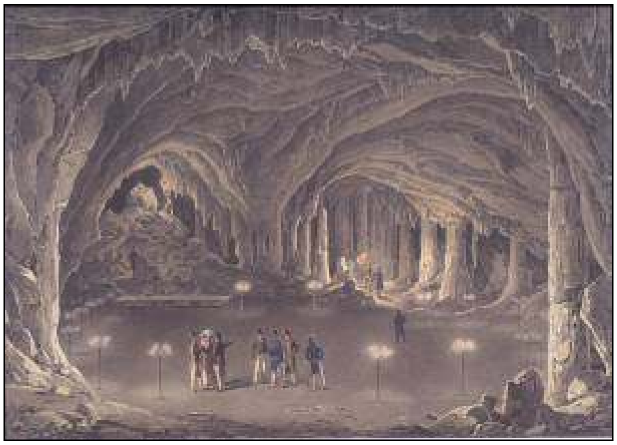
> *The idea seems to have arisen just when maps were showing that hills formed a barrier between the east-flowing Sava and the rivers of the Adriatic basin, and when the existence of caves and underground rivers was becoming more widely known.*

By the 16th century, the Balkan's karst nature was recognized as geographic fact. Quasi-scientific explanation of a classic tale made sense to the the mapmaker.

We briefly visited Postojnska Cave (known as Adelsberg Cave in Austrian times) in Chapter 47, Wrecks of Ancient Life, where we met the blind Proteus and the Slovenian 10-tolar coin.

On an August afternoon of 1850 when water in the cave was unusually low, Adolf Schmidl and his son launched their craft into the cavern, paddling upstream for most of the night. Meanwhile, an evening thunderstorm drenched the surrounding area, and at about 1:00 AM, the river rapidly rose 3 meters, stranding the explorers inside the cave. When the river fell, father and son hastily departed.

The government constructed a gate, an illuminated path, a bridge and a stairway. Torches were banned in favor of clean-burning candles and oil lamps. A rail line was built from to the cave mouth in 1857 and 15 years later, 4 kilometers of narrow-gauge tracks were inside, the guides pushing the two-seat cars.



Postojnska, c. 1834

Postojnska Today

From "The Caverns of Adelsberg," The Ladies' Repository 5, 1870, published by the General Conference of the Methodist Episcopal Church,

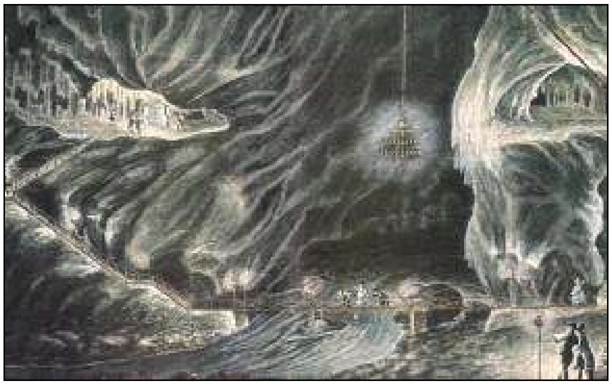
> *This cavern, in common with others in this district, as at Nabrisina and St. Cangian, is under the control of a company, organized under the direction or sanction of the government. They furnish guides, and all needful conveniences for the traveler. They furnish illuminations of any required extent. We secured what they call the "grand illumination," costing some eight or ten dollars. Men had been sent on in advance to begin lighting our 1,600 candles, which, as we afterward found, were arranged in rows and groups along the sides, or at the distant bottom of chasms, or in glorious crowns far above in the domes of the cavern.*
>
> *Suddenly at your right hand, as you look down far below, you catch the flash of a light on its troubled waters at the bottom of a chasm. This river disappears bodily beneath the hill, in the heart of which the cavern is, entering its west or north-west side, lower down than the cavern's mouth. It recalled vividly to my mind the Xanadu, of Coleridge, in which it is said,*
>
> > *Alph, the sacred river ran*
> > *Through caverna measureleu to man,*
> > *Down to a sunless sea.*
>
> *No sooner does the river appear than it disappears in some deeper, and hitherto unexplored, part of the cavern. While we waited the guides run ahead with lamps, and lighted candle after candle, which brought, from time to time, out of the darkness the most unexpected visions.*

The "sunless sea" yet again.

From the New York Times, March 28, 1881,

> *Just below you the furious river goes tearing and foaming down its dark, narrow channel on its way to the outer world, while above stair after stair of rock-cut steps winds slantwise up the face of the cliff, melting at length into the utter darkness that fills the depths beyond... while the hollow roar of the Stygian stream below, the ghostly glimmer of its half-seen waters, the*

> *mighty void of its sunless caverns, which look all the vaster for these tiny specks of light which struggle in vain against the gloom of this shadow of death.*

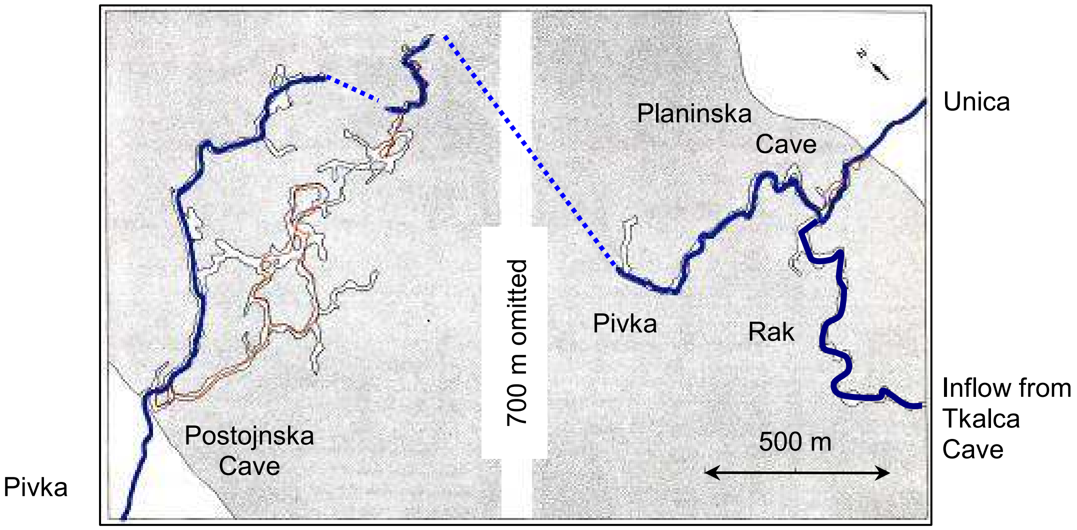


Postojnska Tourism, Victorian-Era

Today's Train Ride

Postojnska
€20.00

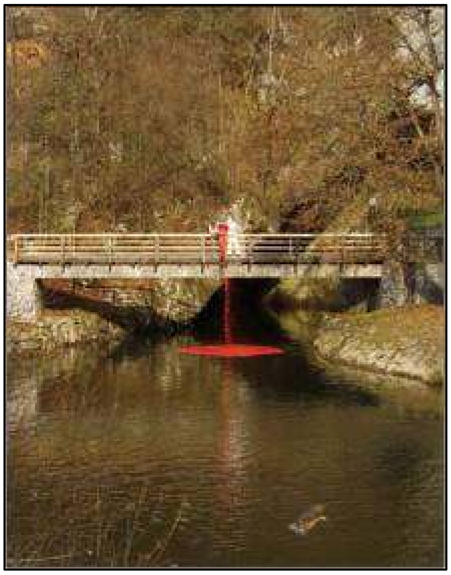
The train loops back to the cave mouth, but the Pivka River, which flows into the cave, makes no such return trip, but continues into what becomes an unexplored route and emerges in nearby Planinska Cave. The price isn't that different than that paid by the Lady Methodists in 1870, but no one today is lighting 1600 candles.



Red lines indicate tourist paths and the railway gallery.

Postojnska had about 1,000,000 visitors per year in the 1980s -- twice the tourist traffic of Mammoth Cave -- but the numbers understandably dwindled with the onset of regional warfare.

To the east, the Rak River flows into Tkalca Cave through an arched entrance and disappears into a sump. We discussed tracers in Chapter 46, Finding the Underground Rivers, but here's a photo of Amidorhodamine G injection of into the sink.



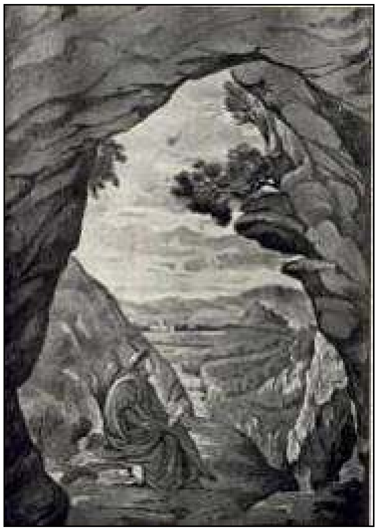
The Rak also reappears in Planinska Cave, where it merges with the Pivka to form the Unica, the largest subterranean confluence in Europe.

A Pivka branch tube journey is shown to the right. The Rak branch is considered too dangerous.

Planinska
€7.00

The sparkling waters gushing from the Planinska mouth attracted travelers as early as the 13th century.

It is said that Dante (Chapter 6) visited the region in 1319, where the cave's ambiance inspired the beginning of Inferno.



Postcard copy of an engraving of Dante in the Tolmino cave.

Modern Grotta di Dante

By the 18th century, the demand for guides, candles and torches spawned a cottage industry.

Krizna Cave is famous for the cave bear bones unearthed in 1876. The skull is still on display. Only 100 visitors/year are allowed on the boat tour which crosses 13 of the 22 known lakes. The price is for a party of three or four.

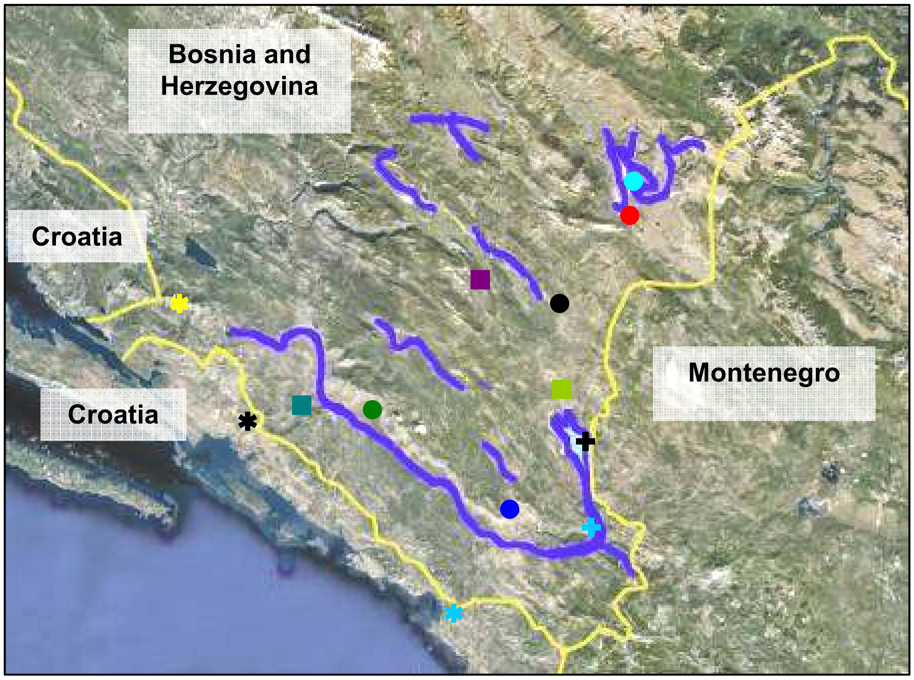
Krizna
€180.00

And now we leave Slovenia, passing through Croatia -- where, had we the time, we could have followed a dozen rivers with subterranean associations -- and into Bosnia and Herzegovina.

Trebisnjica River

Bosnia and Herzegovina's Trebisnjica River runs 98 kilometers above ground and 89 below. The watershed drains 5,000 square kilometers, of which 600 are shared with the Neretva drainage to the north, depending on a reservoir elevation to the south. We're dealing with changing geometries, somewhat akin to the regional politics.

The map below is for location reference. Think of a clock hand sweeping the map from 12:00 to 9:00, but be prepared for an occasional counterclockwise 12:00 to 9:00, when it's high water at 6:00.



Poljes
● Gatacko ● Cernicko ● Fatnicko ● Trebinjsko ● Popovo
Caves and Springs
■ Dejanova ■ Vjetrenica ■ Bregava
Reservoirs
✚ Bileca ✚ Trebinje
Outlets to the Adriatic
✱ Neretva ✱ Slano ✱ Dubrovnik

We'll employ the Serbo-Croatian term "polje," a flat plain in karst territory, typically having an area measured in tens or perhaps a few hundreds of square kilometers. The scientific literature of karstology routinely employs other Serbo-Croatian improper nouns -- techno-speak for those in the know -- but "polje" is the one term that lacks a satisfactory single-word equivalent in English. "Field," has too many other meanings.

The Trebisnjica River originates from two major mountainous streams characterized by sharp, almost erratic bends and changes of direction. Although we're discussing underground rivers, not politics, we can't help but noting that centuries of Balkan history have likewise been characterized by sharp, almost erratic bends and changes of direction. To study underground rivers is so often to study so much more.

The Musnica River flows from the eastern to the western border of the Gatacko Polje.

The Gracanica River flows also into the Gatacko Polje where it meets the Musnica and together they disappear.

The Devon Karst Research Society, headquartered in the United Kingdom, maintains an extensive database on the region. To remind ourselves of recent history, here is the Society's advice regarding Gatacko Polje.

> Parts of Gatacko Polje remain ethnically sensitive areas and we strongly advise visitors from other countries not to wander around or to travel off-road without specialist local guides

Chapters 62-65 dealt with dangers associates with underground rivers. In the Balkans, being shot should be included.

The water re-appears in the Fatnicko Polje, only to sink again after a short run in the sunlight. Discharge varies between 0.4 and 14 cubic meters//second, 85 to 90 percent of which until 1967, reappeared in the head of the Trebisnjica River.

In 1967, the springs were inundated by Bileca Reservoir, but we'll get to Bileca shortly.

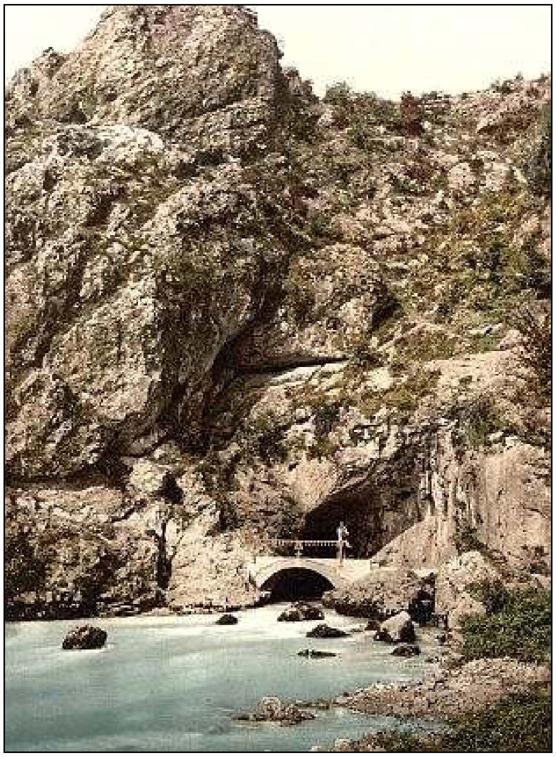
A few facts related to the subterranean journey to the Trebisnjica Spring Group:

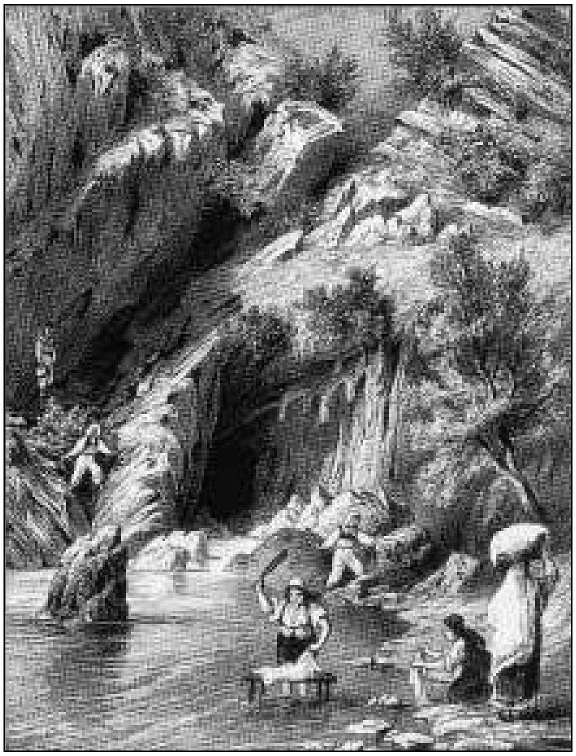
Straight-line distance from furthest Gatacko Polje	34 km
Difference in elevation from furthest Gatacko Polje	520 m
Difference in elevation from furthest Cernicko Polje	480 m
Difference in elevation from Fatnicko Polje	130 m
Travel time from Gatacko Polje at minimum water table	35 days
Travel time from Gatacko Polje at maximum water table	5 days
Mean discharge	80 m3/sec
Maximum discharge	864 m3/sec

The Trebisnjica Springs Group consists of interconnected outlets, the principal ones being,

Dejanova Cave,
Oko Springs, and
Niksicko Springs

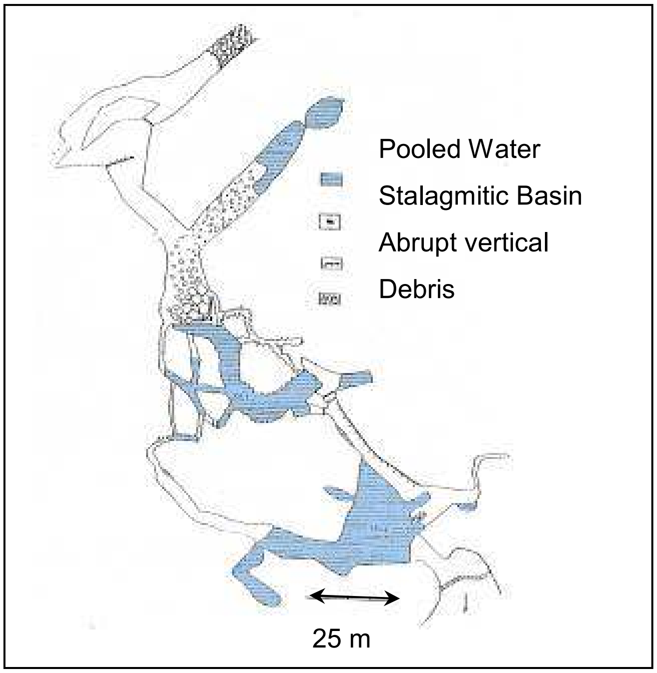
Below is a pair of historic pictures of Dejanova Cave, its entrance, approximately 4 by 6.5 meters.





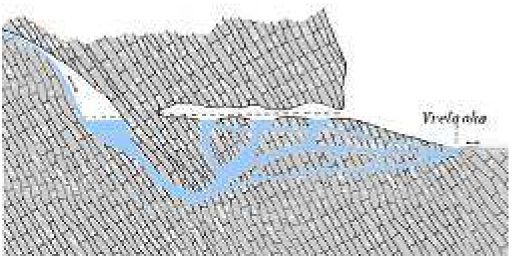
Dejanova Cave,
1890, above left
1900, above right
undated, left

The natural lake within the cave entrance, usually 1.5 meters below the lip, would rise after periods of heavy rainfall to discharge streamflow under the arched bridge. The depth of the lake was about 1 meter, but increased in the greater part of the chamber.


Pooled Water
▨ Stalagmitic Basin
▨ Abrupt vertical
▨ Debris
▨
25 m

Cave passages are shown to the left.

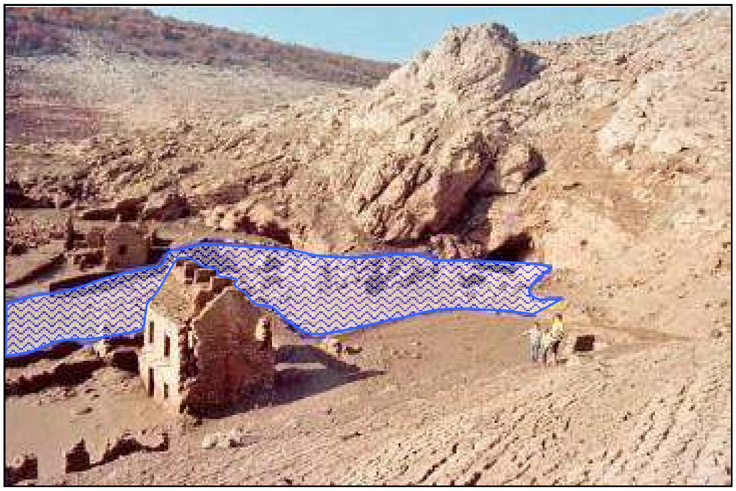
The cross-section shows the inverted siphon connections to Oko Springs, five springs in itself, 200 meters downstream.



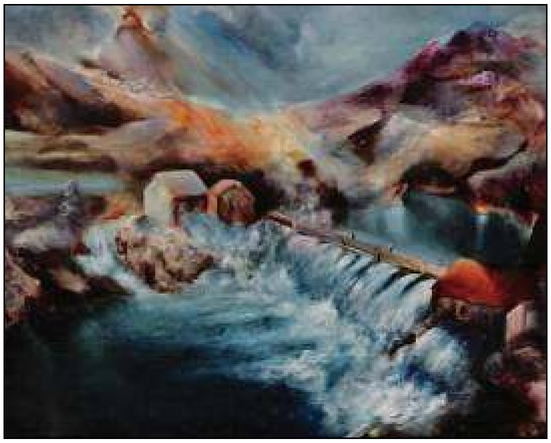
.

Local merchants constructed water mills on opposite river banks after World War I, creating an artificial lake which inundated both the arch bridge and the lower portion of the cave entrance.

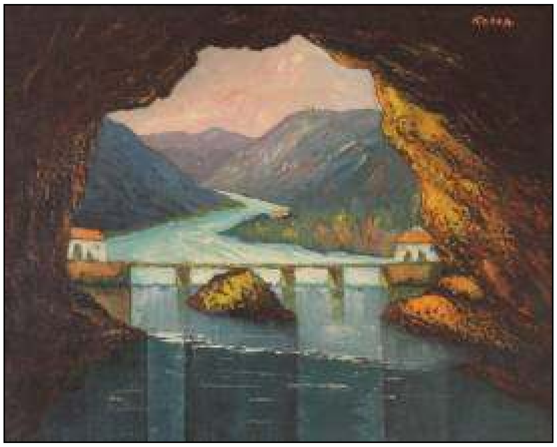
Thanks are due to Trebisnjica historian Dragan Tabakovic for his contributions to this chapter, this photo-reconstruction of the mill pond being just a small portion.



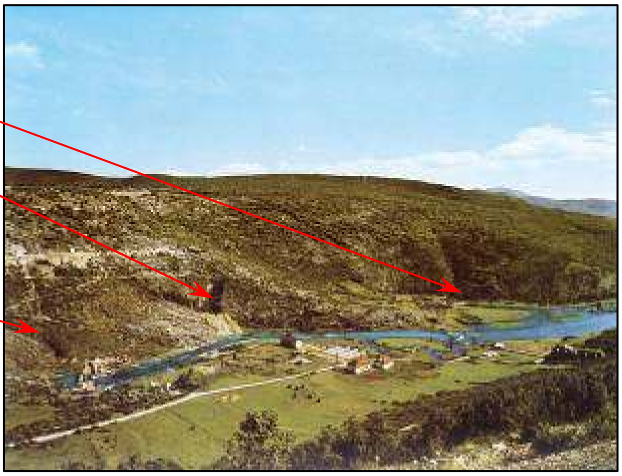
The paintings of the mills below are from Tabakovic's archives.



Dejanova Cave Mills by Zivko Janjic



From within Dejanova Cave by local artist Kokolj



Photo, ca. 1960

Niksicko Spring joins the main flow at the second bend

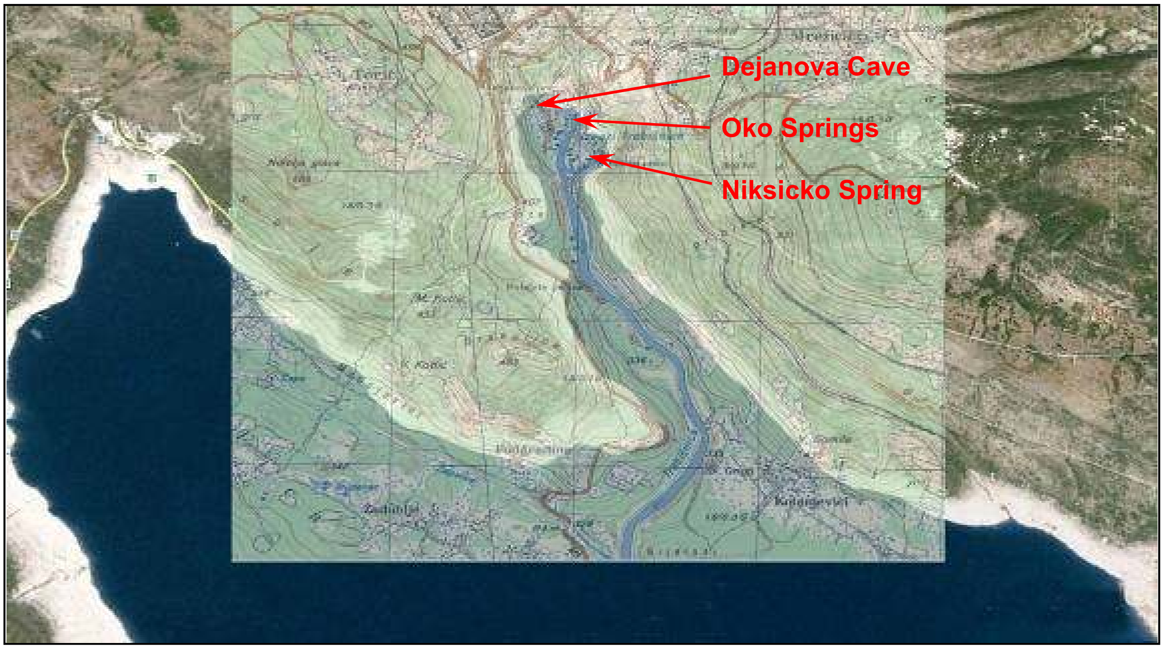
Oko Springs, with its large exit gulley, is opposite the red-roofed Hotel Trebisnjica.

Dejanova Cave

But even that's now history, thanks to 75-meters of inundation by the 1.3 billion cubic-meter Bileca Reservoir. Completed in 1968, the project was the former Yugoslavia's greatest public work. Storage in the karst between the reservoir and Fatnicko Polje is estimated to add another 0.2 billion cubic-meters.

Bileca Reservoir from approximately the same viewpoint as the pre-1967 photo.

The superimposed pre-1967 topographic map and current aerial photo shows the inundation in plan view.



The 16th-century Arslanagic Bridge was dismantled and moved 3 kilometers downstream as a continuation of the second stage of the hydropower system. Although of similar Turkish architectural style, our Dejanova Cave arched footbridge, alas, didn't fare as well. The photo to the right, just prior to inundation, is our adieu to the quaint crossing.

Arslanagic Bridge, Relocated

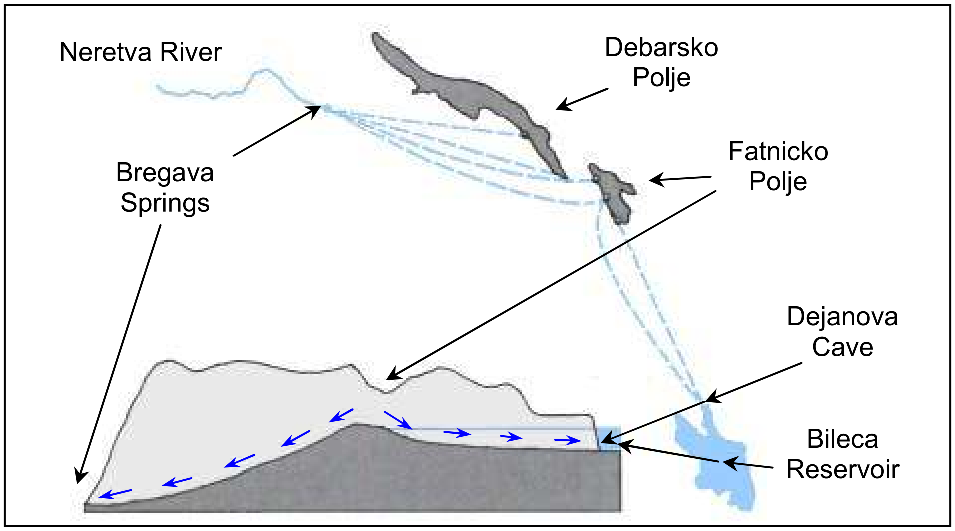
Dejanova Cave Bridge, Submerged

Trebinje Reservoir, a smaller structure, was built downstream.. A 90 cubic meter//second tunnel from the reservoir powers a hydroelectric plant near Dubrovnik, Croatia. An additional channel is directed to the Capljina power plant in Herzegovina.

As tabled below, Bileca Reservoir can affect the hydrologic functionality of Fatnicko Polje.

Elevation (meters above sea level)	
460	Fatnicko Polje
420	Bluff above Dejanova Cave
400/402	Reservoir spillway
400	Reservoir level at which Fatnicko Polje begins to drain westward
370	Reservoir level at which Fatnicko groundwater level beings to rise
325	Dejanova Cave entrance
315	Riverbed in front of Dejanova Cave
296	Riverbed at dam

In pre-reservoir days, Fatnicko Polje spanned the drainage divide between the Trebisnjica watershed to the south and Bregava Springs in the Neretva watershed to the west. What happened on either side didn't affect the other.

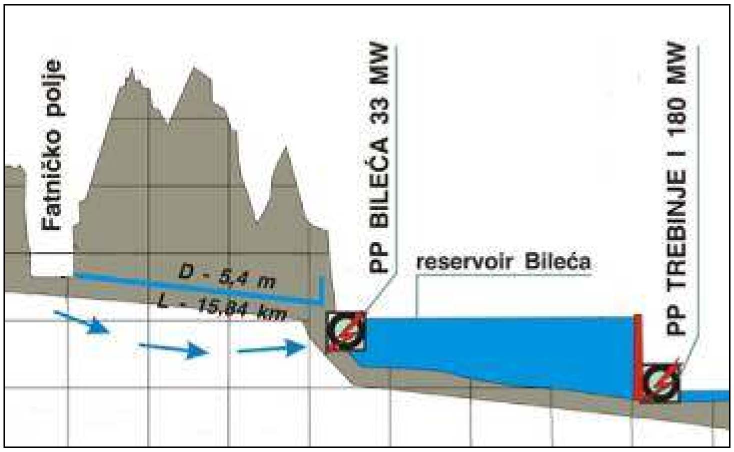

Neretva River
Debarsko Polje
Bregava Springs
Fatnicko Polje
Dejanova Cave
Bileca Reservoir

Today, however, at reservoir level 370 meters, the subterranean backwater is observed at Fatnicko Polje. At elevation 400, that of the subterranean ridge, there is no water slope to the south and percolation redirects westward to the Neretva.

As it's beyond our scope to summarize the configuration, complexities and predicted consequences of current and proposed hydroelectric development, we shan't go there. It's just another factional Balkan war, this one waged with consultants. We will, however, note one small component, an underground augmentation, so to speak.

We just saw that Dejanova Cave flow from Fatnicko was good enough for the washer-woman, but the karst channel is insufficient for hydropower. As part of the region's Upper Horizon project, a 5.4-meter tunnel was begun in 1986, suspended for armed conflict, resumed in 2002 and completed in 2009.

Fatnicko Entrance


Fatničko polje
D - 5,4 m
L - 15,84 km
PP BILEĆA 33 MW
reservoir Bileća
PP TREBINJE I 180 MW

The power plant itself, however, is still on hold.

The tunnel's local environmental consequences may include

Increased local flooding at Bileca, already documented,
Shrub growth (already observed) due to lack of tunnel lining and/or karst backwater, and
Increased subterranean salinity, predicted but not yet verified

Regional environmental consequences, potentially more severe, may stem from inter-basin transfer. Augmenting a subterranean river without environmental detriment is not easily achieved.

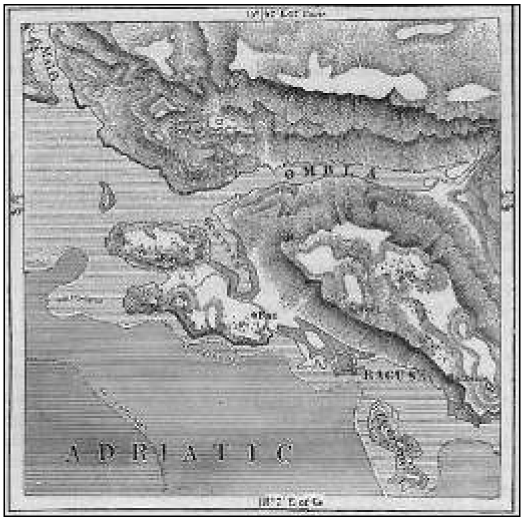
We'll catch up with the Neretva a bit later, so back to Bileca.

Spill from the reservoir turns west into the Trebinjsko Polje, and follows the southern mountain slopes to Popovo Polje, the largest karst field in the Balkans. To reduce loss, the riverbed was blanketed with gunite for 67 kilometers in 1979.

Vjetrenica Cave ("wind cave"), the largest cavern in Bosnia and Herzegovina, runs from the edge of Popovo Polje and has been explored for 6 kilometers, but it could stretch 15 to 20 kilometers to the Adriatic. While the cave conveys some Trebisnjica seepage, however, it's not a major abstraction.

The river then curves north near the Croatian border and again sinks, re-emerging for its finale in three outflows,

1. After some 20 kilometers underground, the Ombla River rises as a cave spring near Dubrovnik, from where it flows 4 kilometers to the sea. Mean discharge is 24 cubic meters/second, with a range of 2.3 to 112.5. The Ombla has been used for Dubrovnik's water supply since 1437



To the right, an 1883 relief map of the Ombla River. Above, Ombla Spring today..

2. As submarine springs ("vrulje" or "boiling water") near the harbor of Slano, northwest of Dubrovnik.

3. As springs feeding the lower Neretva River, the watercourse fed by Bregava Springs, which -- as previously noted -- also draws from Fatnicko Polje when Bileca Reservoir is high.

Here's a excerpt from "Herzegovina," a traveler's impression by A.J. Evans in Turkey and the Balkan States, as Described by Great Writers (1908), edited by Esther Singleton.

> *The "polyes," or mountain plateaus, are the most characteristic feature of the country. The smaller towns and villages group themselves on their level and comparatively fertile surface, and the districts, or cantons, thus formed are walled round by a natural rampart of white limestone mountains. These "polyes " may be described as oases in what is otherwise a desert expanse of mountains. The surface of some, as notably the great Mostarsko Blato, is marshy, and in spring forms a lake; others are watered by streams which disappear in swallow-holes of the rock, and make their way by underground channels either to the sea or the Neretva. The most conspicuous example of these is the Trebinjsca, which disappears in two swallow-holes in Popovo Polje, and after making its way by a subterranean passage through a range of mountains, wells up in the mighty source of Ombla, near Ragusa, and hurries in undiminished volume to the Adriatic.*

The intervening century, however, hasn't gone well. The Devon Karst Research Society's notice regarding Popovo Polje today:

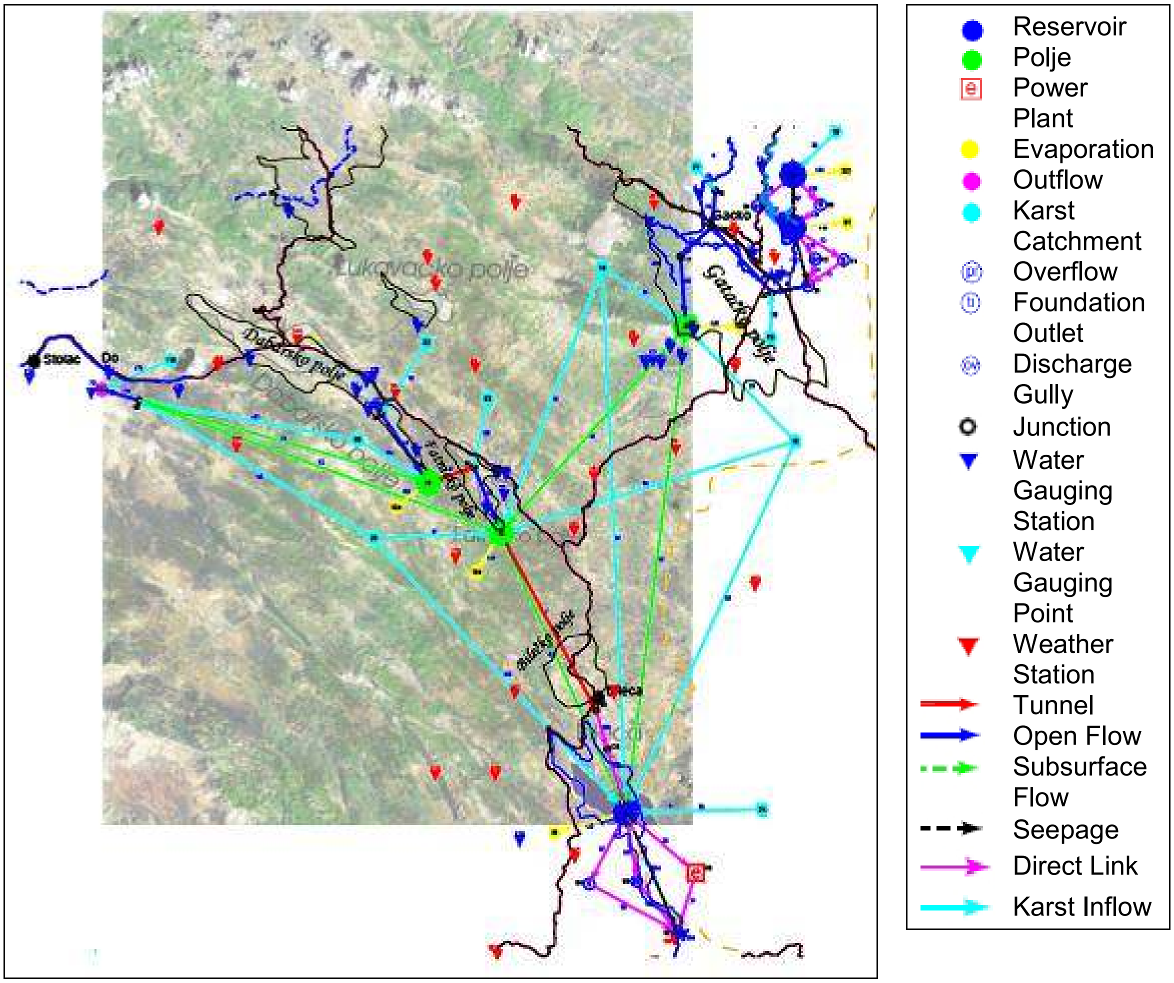
> There are numerous obscured ammunition dumps in the Strujici to Kotezi area and un-cleared minefields and mined buildings in certain parts of the Polje from Zavala to beyond Ravno further west and in Trebinjsko Suma either side of the former front-line areas. Additionally, there is widespread occurrence of sundry unexploded ordnance both on the surface and underground. Concrete bunkers in the former front-line areas invariably contain unexploded munitions and may also be mined. Mine warning signs are not always in evidence.

And speaking of armed men in the Balkans, underground rivers are particularly associated with those from Albania, or at least were so in the past. From The New Student's Reference Work (1914),

> *Albania (al-ba' ni-ä) is the southwestern part of European Turkey. It is about 290 miles long from north to south, and from 40 to 50 miles in width. The country is mountainous, and is noted for its underground rivers and beautiful lakes. The Albanians are mountaineers and many of them brigands.*

We can only wonder how the officials tasked to manage the water resources manage to do so.

To illustrate the level of detail required to scientifically oversee the system, we present a schematic of the Trebisnjica's water balance, each symbol a set of rules and equations.

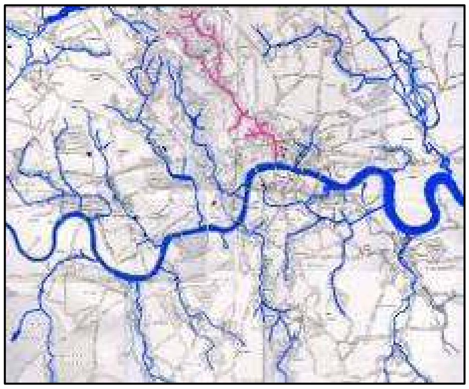

Stolac
Do
Lukovacko polje
Dabarsko polje
Fatnicko polje
Gacko
Gatacko polje
Bilecko polje
Bileca
● Reservoir
● Polje
Power Plant
● Evaporation
● Outflow
● Karst Catchment
Overflow
Foundation Outlet
Discharge Gully
○ Junction
▼ Water Gauging Station
▼ Water Gauging Point
▼ Weather Station
→ Tunnel
→ Open Flow
→ Subsurface Flow
→ Seepage
→ Direct Link
→ Karst Inflow

Could the logistics of ethnic conflict involving arbitrary borders and vigilante armed forces be any more difficult to follow?

CHAPTER 73
THE SINKING OF THE FLEET

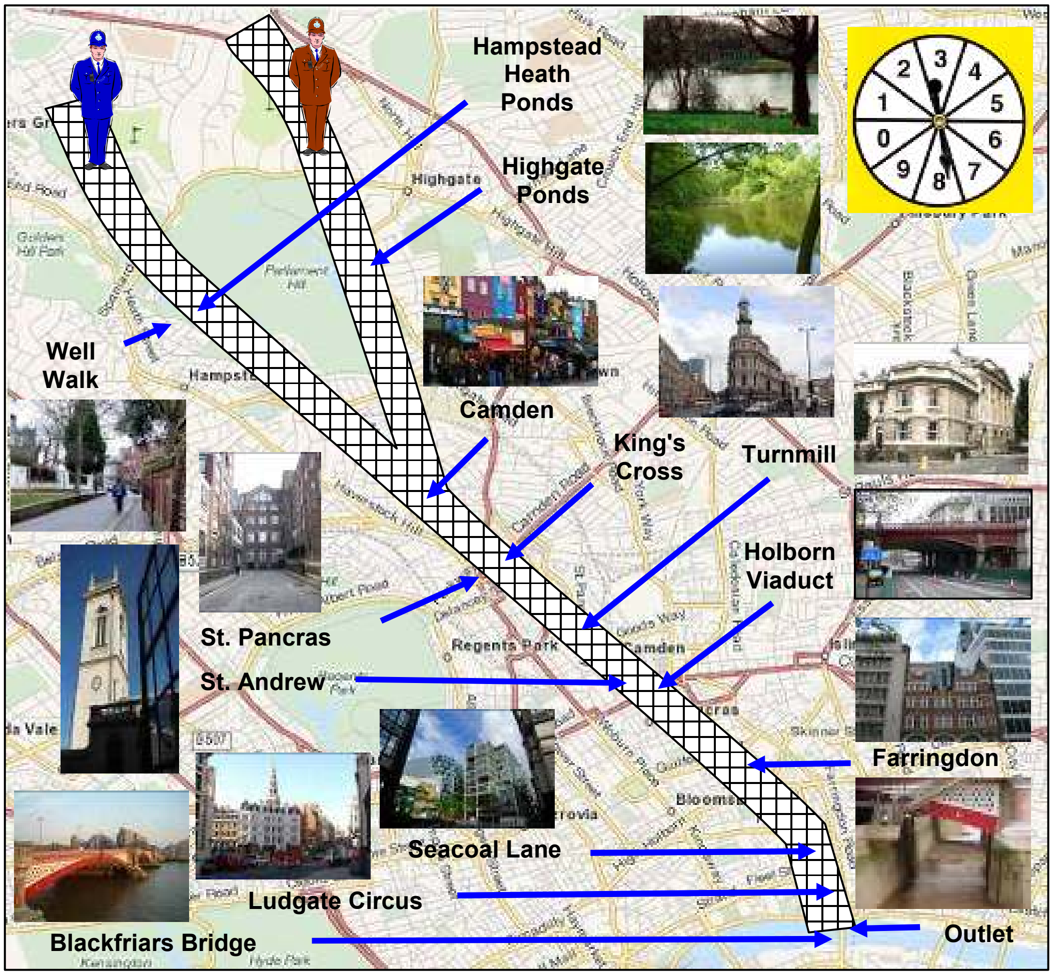
Thirtreen rivers have gone missing in London Town:

The Westbourne
The Walbrook
Stamford Brook
Hackney Brook
The Peak
The Falcon
The Fleet
The Effra
The Tyburn
Counter's Creek
The Neckinger
The Earl's Sluice
The Wandel



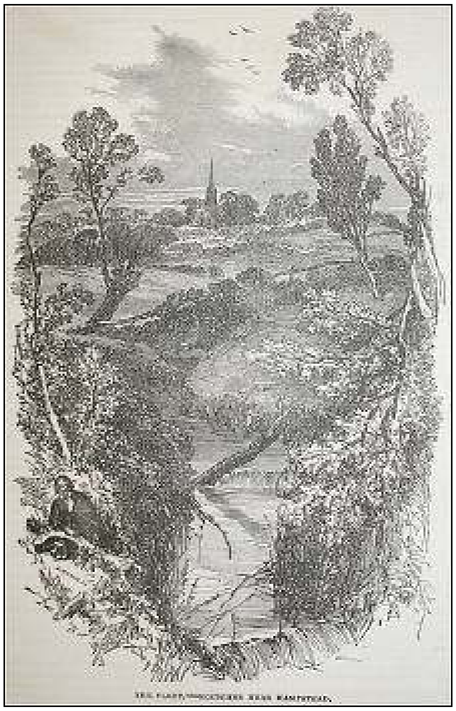
We'll investigate just the last, a river last seen flowing toward the Thames in the 1870s. The lost river was said to be of gentile origin, but odiferous and pestilent where it had interacted with the lower classes.

We've invented a game we'll call "Follow the Fleet." Choose your bobby and spin the spinner.


Hampstead Heath Ponds
Highgate Ponds
Well Walk
Camden
King's Cross
Turnmill
Holborn Viaduct
St. Pancras
St. Andrew
Farringdon
Seacoal Lane
Ludgate Circus
Blackfriars Bridge
Outlet
1
2
3
4
5
6
7
8
9
0

For those less sporting, the game board may be used as a reference for the remainder of the chapter.

The waters of the Fleet emerge about 100 meters above sea level on the slopes of Hampstead Heath in Northwestern London. The river was known as the "River of Wells" in the Middle Ages when London was more renown than Lourdes for the healing qualities of its springs. Water from Chalybeate Well (on today's Well Walk St.), rich in iron, was sold in London markets.



River Fleet near Hampstead, Illustrated London News, 1854

The top of Hampstead Heath is the only place where the River Fleet now flows on the surface

Today's Heath ponds were formed in the 17th century when the upper reaches of the watershed were dammed to supply drinking water to St. Pancras.

Hampstead Heath

Highgate

CORPORATION OF LONDON
WOMEN ONLY
MEN NOT ALLOWED BEYOND THIS POINT
PUBLIC TOILETS 200M

Hampstead
Heath Bathing
£2.00

Hampstead springs have long been spa sites and the City of London Corporation yet operates the pools for year-round bathing, one for men, one for women, and one for mixed swimming

The last sign of the superterranean River Fleet, however, is at the bottom of the lower Highgate pond where the flow drops into a grate.

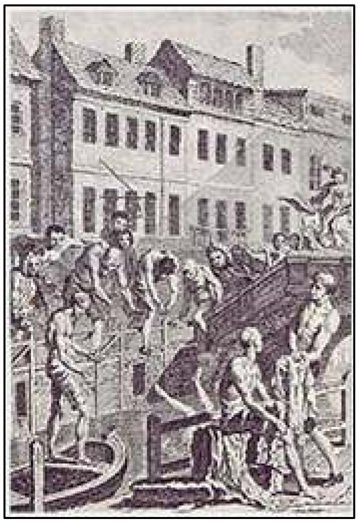
So thus we must look at history, which being of London, is in no small quantity.

In the Fleet's 7-kilometer descent, the forks originally amalgamated in Camden, then flowed through St Pancras and Kings Cross as a stream up to 20 meters in width, further widening through what would become Farringdon St. with enough flow to turn a mill at what's now Turnmill St. and enough depth to coal a ship at what's now Seacoal Lane. Fleet Bridge was built in about 1180 at what's now Ludgate Circus. The Fleet created an estuarial basin 200 meters wide.

By the 12th century, however, the area was given over to derelict housing and prisons and the stream became choked by filth. Tanneries discharged offal and skin scraps. Butchers added rotten animal parts. The Whitefriars at the mouth of the Fleet complained that the stench overpowered their incense.

As more water was withdrawn during the 13th century, the Fleet became shallower, frequently silting up with rubbish. Well-to-do Londoners yet flocked to the Hampstead spas, but the river further downstream gradually became a conduit for the spread of disease.

In a 1355 inquiry regarding the state of the stream, jurors recommended it be at least 3 meters broad and of sufficient depth to float a vessel freighted with a ton of wine, but the river failed even that test.



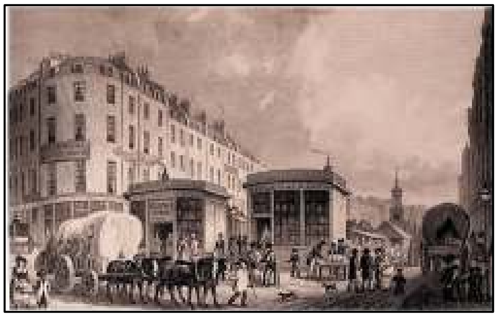
In 1598, John Stow wrote in his Survey of London that there were five bridges over the Fleet, and the river was,

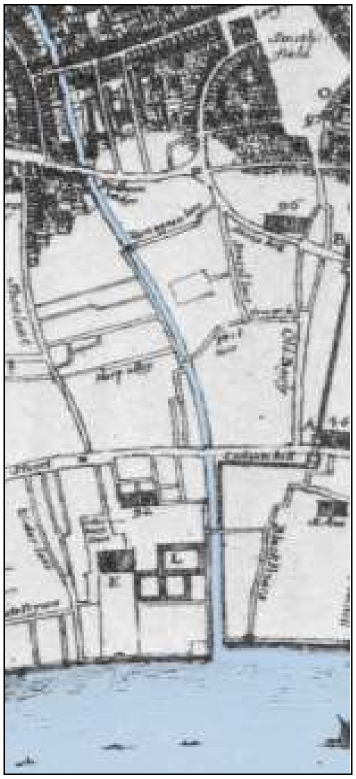
> *Impassable for boats, by reason of the many encroachments thereon made, by the throwing of offal and other garbage by butchers, saucemen and others, and by reason of the many houses of office* [toilets] *standing upon it.*

Royal Orders were issued in 1652 for the stream's cleansing and preservation, but it was reconstruction after the Great Fire of London, 1666, that provided Christopher Wren the opportunity to renovate the river's lower reach in the style the Great Canal of Venice.

Alas, however, the 1728 etching of emaciated bathers is a comment on the Royal Orders and Sir Christopher's efficacy regarding sanitation.

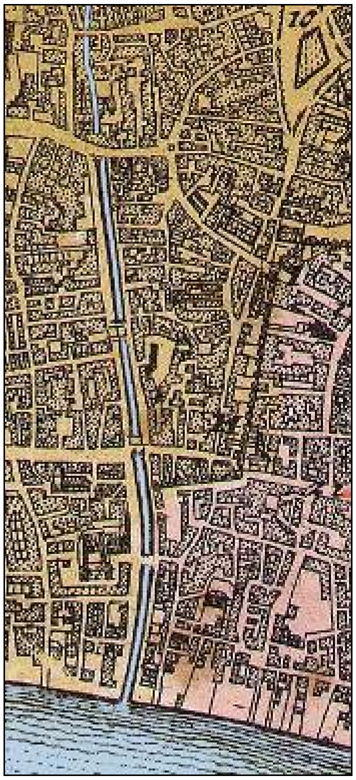
It was the rise of real estate prices, coupled with mercantile demand to diminish the noxious odors, that initiated the river's first stage of disappearance in 1737 when Fleet Market, two rows of shops, arched the channel between the Fleet and Holborn Bridges.





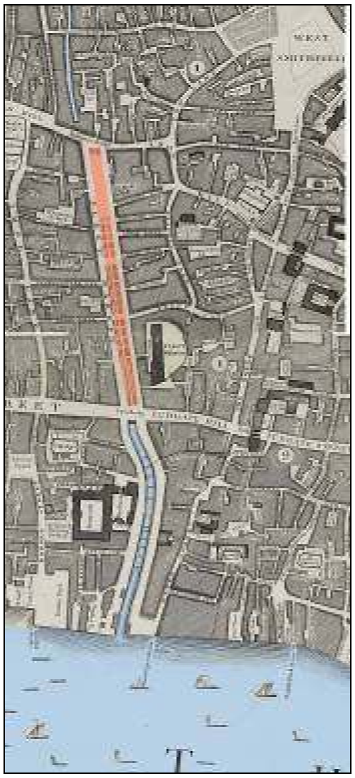
Map of 1666

The year of the Great Fire of London



Map of 1705

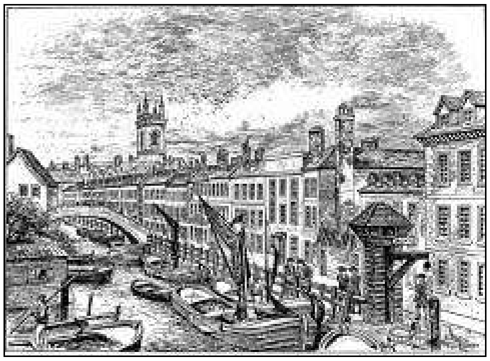
"New Canal," navigable to Holborn Bridge, constructed in 1669-1673



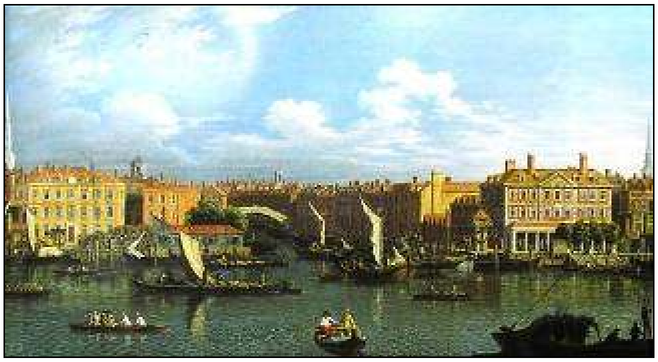
Map of 1746

Fleet Market, consisting of two rows of shops arching the river, opened in 1737

We can see in the pictures below Wren's architectural influence on the Fleet Bridge and at the same time, gain an appreciation of the Fleet as a viable wharfage.



Fleet River, St. Andrew Church in Background (c. 1700)

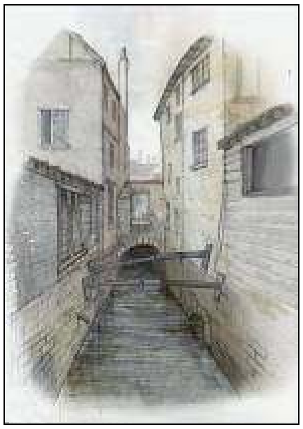


The Mouth of the River Fleet as depicted by Samuel Scott (c. 1750)

The feasibility of covering the river spread, however, by the 1810s the Fleet was covered from Kings Cross to Camden.

Out of sight, but as the day's covering wasn't always vapor-proof, now necessarily out of smell. Below is a ditty of 1839.

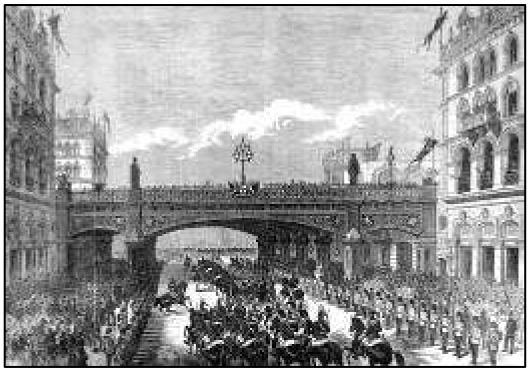
> *Will you go to Bagnigge Wells, Bonnet builder, O!*
> *Where the Fleet-ditch fragrant smells, Bonnet builder, O!*
> *Where the fishes used to swim, So nice and sleek and trim,*
> *But the pond's now covered in, Bonnet builder, O!*



Right: Fleet Sewer, West Street, c. 1844

Or from something more recent,

> *Confined underground in phases between the 1730s and 1870s the allure of centuries old brick built tunnels under London still outweighs the thoughts of trudging through a river of detritus. The water flows underground for 4 miles (6.4 kilometers) to join the River Thames.* -- Michael White, Isaac Newton, The Last Sorcerer (1999)



Fleet Market was demolished in 1820, becoming Farringdon St., which in turn was canopied in 1869 by Holborn Viaduct at the former site of Holborn Bridge.

By the 1870s, the entire river, apart from the few hundred meters below the source springs, had been relegated underground.

As lamented by Charles Dickens in "Clock Fast, Five Hundred Years", All the Year Round, April 25, 1863,

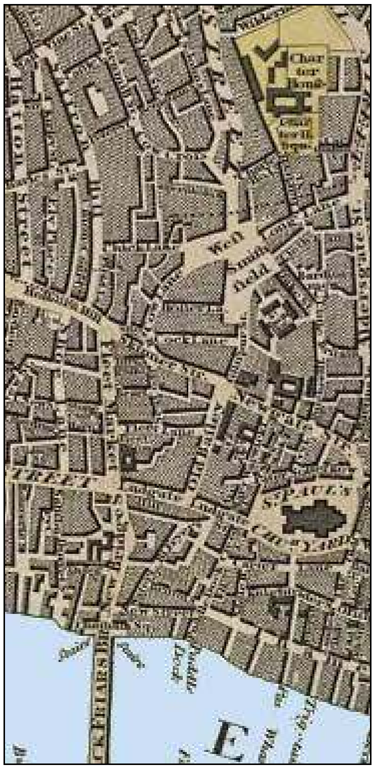
> *Thames! Why you don't suppose in all these years we have stood still at your old strips and shreds of bridge. It is all bridge now, my boy. Thames is an underground river, at least as far*

> *as Gravesend. It runs under that sweep of preen playground. And there is plenty of traffic, be sure, of which in these good days that are come, we no more see the circulation on the face of the town, than we see the circulation of the blood -- otherwise than as a bloom of health upon my sister's face there. All you see on the surface of this lovely London is the bloom."*

"Up the Thames," Lippincott's Magazine of Popular Literature and Science, January 1876, provided another opinion, a bit more erudite.

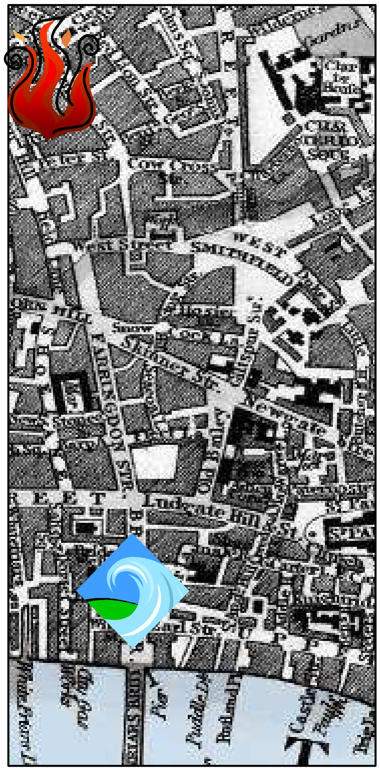
> *The Thames is hereabouts joined from the south by a somewhat exceptional style of river, characterized by Milton* ["At a Vacation Exercise in the College"] *as "the sullen Mole, that runneth underneath," and by Pope* ["Windsor Forest"]*, in dutiful imitation, as "the sullen Mole that hides his diving flood." Both poets play on the word. In our judgment, Milton's line is the better, since moles do not dive and have no flood -- two false figures in one line from the precise and finical Pope! Thomson contributes the epithet of "silent," which will do well enough as far as it goes, though devoid even of the average force of Jamie. But, as we have intimated, it is a queer river. Pouring into the Thames by several mouths that deviate over quite a delta, its channel two or three miles above is destitute in dry seasons of water. Its current disappears under an elevation called White Hill, and does not come again to light for almost two miles, resembling therein several streams in the United States, notably Lost River in North-eastern Virginia, which has a subterranean course of the same character and about the same length, but has not yet found its Milton or Pope, far superior as it is to its English cousin in natural beauty.*

Lost, but not out of power, we might say, as an 1846 sewage gas explosion near King's Cross sent a tidal wave of filth through the streets, demolishing buildings and ramming a boat on the Thames into Blackfriars Bridge.



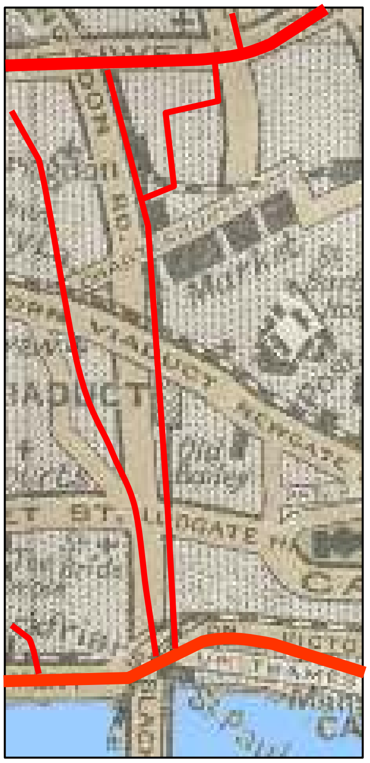
Map of 1807

New Bridge Street covering the reach to the Thames



Map of 1846

Sewage gas explosion.

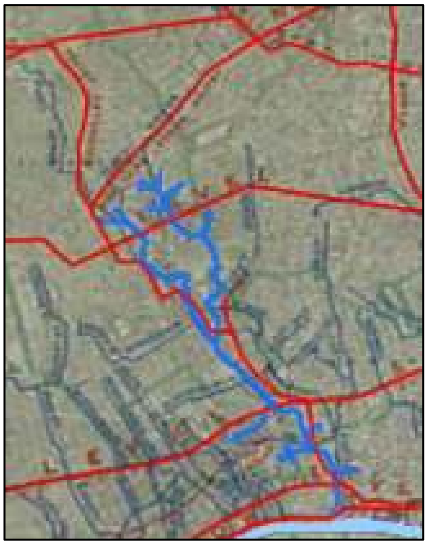


Map of 1900

Interceptor sewer system designed by Joseph Bazalgette.

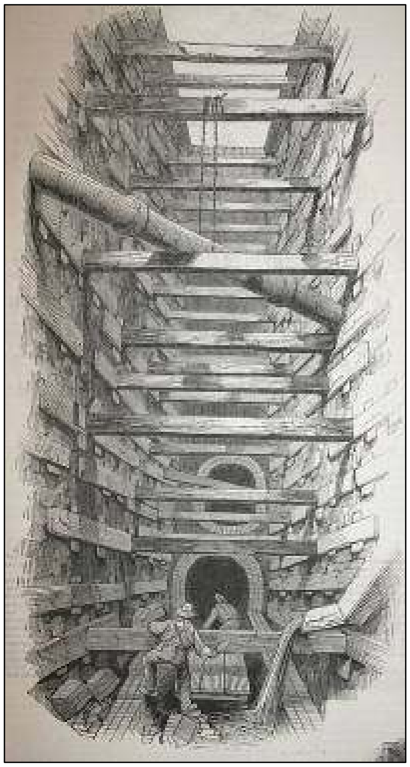
The problem, of course, is that a river sent underground still has a mind to follow the easiest downhill route.

The backbones of Chief Engineer of the Metropolitan Board of Works, Joseph Bazalgette's 318-million-brick sewer system, built between 1859 and 1865, were west-to-east interceptors. These interceptors, shaped like an upside-down horseshoe with a relatively-flat concave floor, carried the flows from smaller round or oval tunnels fed by local flows to pump stations where the waste was stored in reservoirs. At high tide, the reservoir outlets were closed and the sewage accumulated. At low tide -- the difference being as much as 2 meters -- the outlets were opened and the effluent drained to the lower Thames.



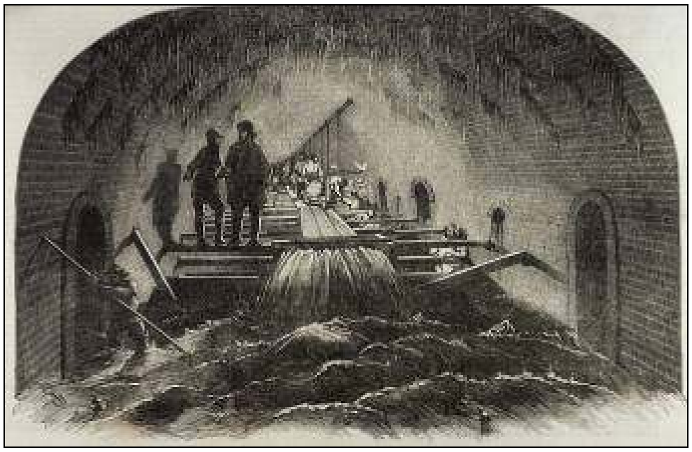
Shown to the right is our portion of Bazalgette's system, the original north-to-south course of the Fleet -- shown for orientation, as the river was by now long buried -- transected by three west-to-east interceptors.

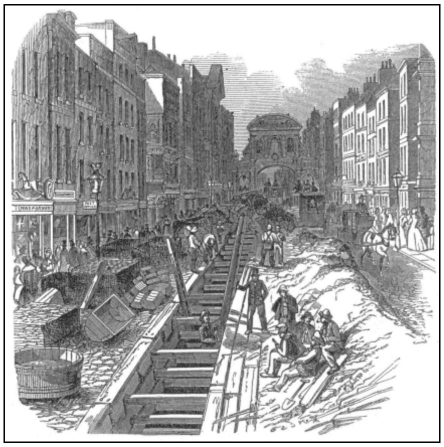
Before City-wide sewerage, the River Fleet was still the River Fleet, just underground. Now even that claim couldn't be made, as progressive reaches of the river have been purloined out of the watershed.



Illustrations and reports from the Illustrated London News of 1845 and 1854,

> *One of the oldest Sewers, if not actually the oldest, in the metropolis, is the Fleet; once an open river, which, as Stow tells us, "had been of such breadth and depth, that ten or twelve ships' navies at once, with merchandise, were wont to come to the aforesaid bridge of Fleet" – is still a river, although hidden from sight; the waters of the Highgate and Hampstead hills still run through it; the old Bourne (now also a sewer) still delivers its waters into it; but, in addition to this, from running through a dense population, it probably received and discharges more sewage water than any other sewer in the metropolis.*





As for a vivid sense of the darkened journey, "Through London by Canal," Harper's New Monthly Magazine, May 1885, cites an early traveler of the enclosed waterways.

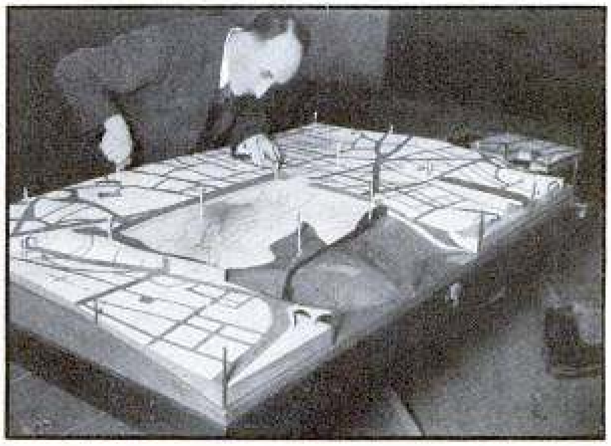
> *The passage by steam-tug has a truly Tartarean aspect: the smoke, fire, noise of the engine, the black gloom of the arch, the blackness of the water, the crashing of the barges against the sides of the tunnel, the lurid light gleaming at each extremity, from an aggregate of infernalia.*

Today, these lost rivers do more than flow to the Thames. From "Underground River to Cool Passengers Sweltering on Tube," Times Online, July 15, 2004,

> *A revolutionary cooling system is to be installed on the London Underground that will draw on the millions of gallons of water pumped out of the deep tunnels each day.*
>
> *The system will be fitted first at Victoria, one of the busiest Tube stations, and is expected to reduce summer rush-hour temperatures on Victoria Line platforms by between 5C and 6C.*
>
> *Tube trains will push the cooler air along the line, bringing relief to the hundreds of thousands of passengers who endure sweltering conditions on the Underground.*
>
> *The cooling system takes advantage of the Underground's existing pumps, which prevent the capital's rising water table from flooding the network. Water will be extracted from boreholes at a temperature of 14C and pumped to heat exchangers located in rooms between platforms. Fans will blow hot air from the stations across water pipes. The water temperature will rise by a few degrees as it extracts heat from the air.*
>
> *The cooler air will then be blown back on to the platforms and the warmer water will be pumped into the Thames. At Victoria, where a trial of the system will begin before next summer, more than 200 liters a second will be drawn from the underground River Tyburn.*

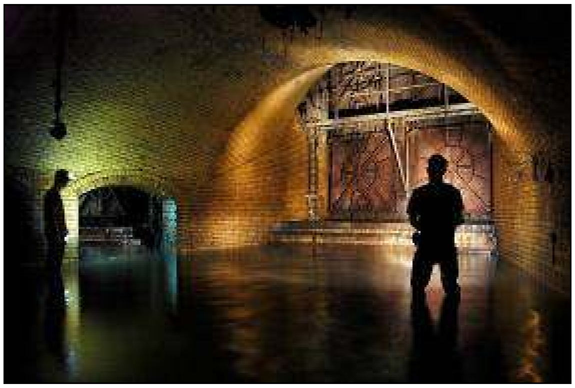
And while we're near Fleet St., the former Central Telegraph Office is just around the corner. From Popular Science, June 1934, "Model Shows London's Buried Lake"

> *To aid in planning a restricted building area in London, England, engineers have just completed a five-foot model of one of the city's strangest features. This is a subterranean lake long unsuspected and only recently discovered, twenty-six feet beneath the city's central telegraph office. The lake is estimated to be at least sixteen feet deep. To show how its presence might affect building plans, the scale model was constructed with a removable top.*



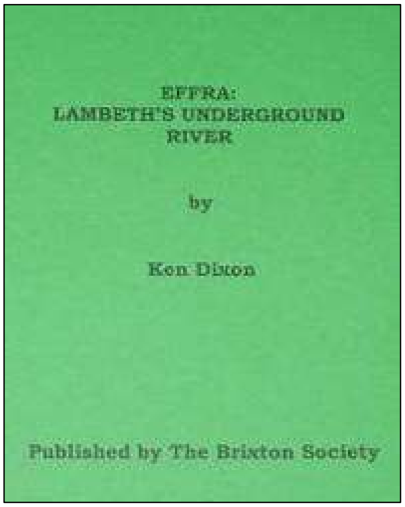
Where there's an underground river, it stands to reason that there might be an underground lake, we expect that the writer meant "aquifer."

Although London's modern sewerage network has been since upgraded, Bazalgette's Fleet diversion can still be inspected.



And at last we've arrived at the Thames, where what minimal remains of the Fleet outflow, emerges beneath Blackfriars Bridge.

The Fleet's not London's only underground river. Take, for example, Effra: Lambeth's Underground River (1993) by Ken Dixon about a district of south London. For more than a century this river has been enclosed, but before urbanization, the Effra ran as an open stream.



EFFRA:
LAMBETH'S UNDERGROUND
RIVER

by

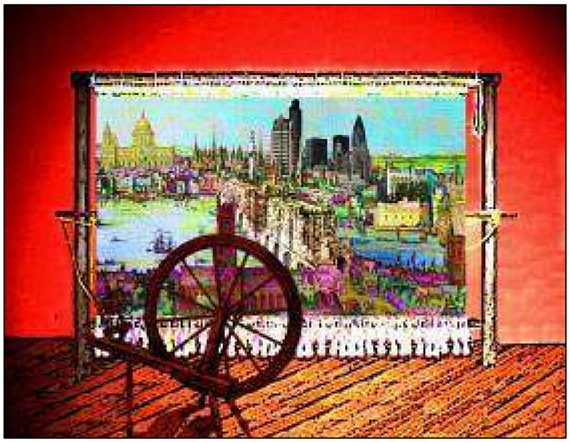
Ken Dixon

Published by The Brixton Society

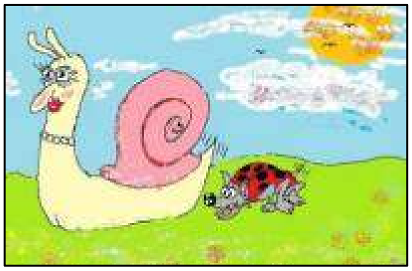
The underground river is woven into British legend. Thomas Learmont, better known as Thomas the Rhymer, was a 13th century Scottish laird and reputed prophet, the hero of "Thomas the Rhymer" in Sir Walter Scott's Minstrelsy of the Scottish Border (1804).

> *O they rode on, and farther on,*
> *And they waded thru rivers above the knee,*
> *And they saw neither sun nor moon,*
> *But they heard the roaring of the sea.*

In **Paul Andruss**' contemporary retelling of the Rhymer tale, a fairy queen weaves her life into a tapestry which when touched, provides passage into the legend and onto on a fairy road running along a river beneath London, emerging in the Thames.



And even as we depart the sub-London waterways, Adventures of Izzy the Snail (undated internet publication) by Fenella Shorty is passing the lore to the next generation.



> *"Good afternoon, Sir," a beetle called Ringo emerged from under a leaf. "I am glad to see you, as I was about to make my way to the Police station to report an incident. I heard someone screaming round here earlier. Someone has fallen into one of the hidden holes in this tree."*
>
> *"Oh no!" Sergeant paused for a moment. "Below the tree, there is an underground river that leads to the River Thames..." he said. "The snails are in great danger. We must run to their rescue! Ringo, thanks, you are a star."*

Ringo Starr, of course, sang "Yellow Submarine" and the Beatles' movie was of somewhat similar plot, but we haven't the time to follow every underground channel braid.

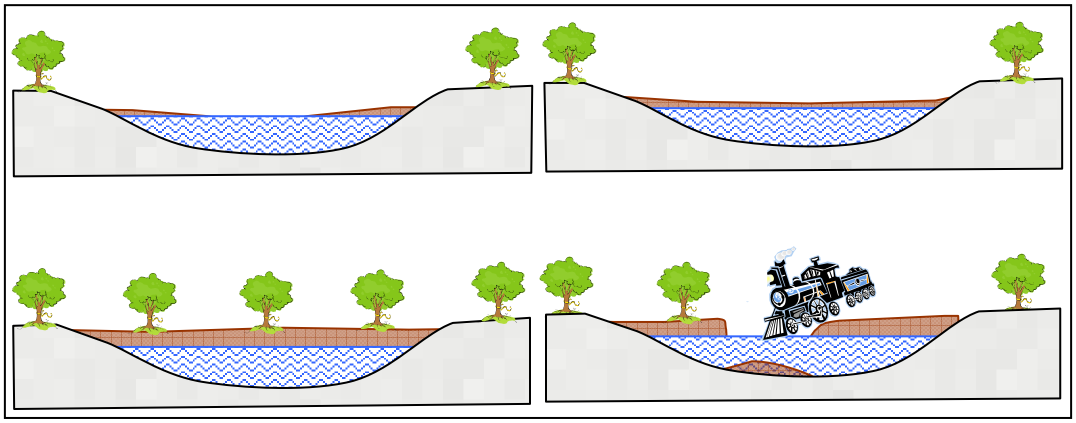
Few subterranean streams are so historically complex, but as we've come to recognize, underground rivers follow a myriad of routes, not all of which stem from geology.

CHAPTER 74

RAILROADS AND INCRUSTED LAKES

Lake incrustation, a subject with which we may be unacquainted, is the geologic process in which a lake's surface becomes progressively covered with earth, which in turn comes to superficially resemble that surrounding. Such encrustation, however, may not support a locomotive.

Our entire chapter may be reduced, in fact, to the following graphic.

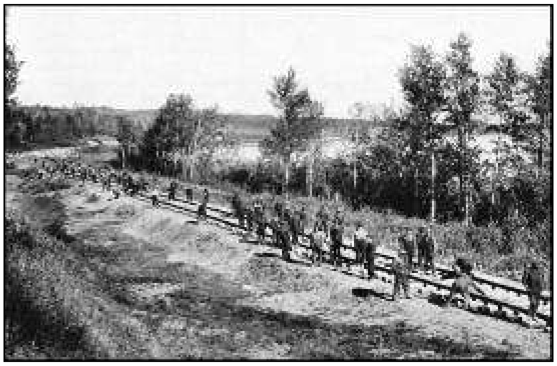


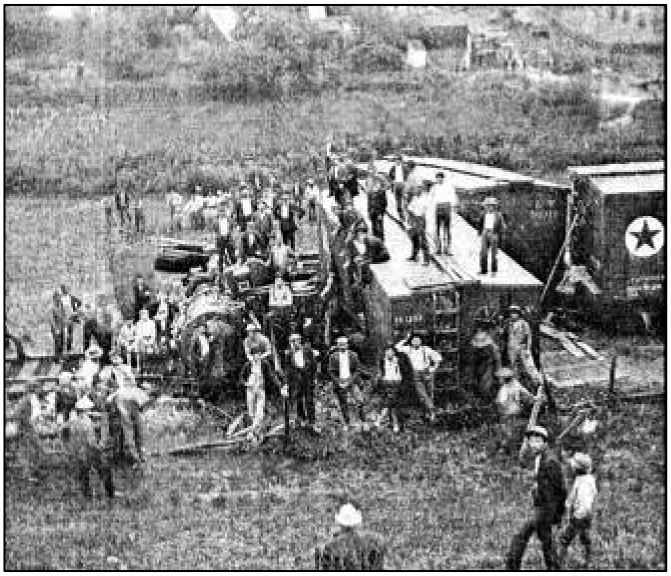
Lake Incrustation and Railroad Derailment

For those who question the premise of land suspended upon water, we have the authority of American railway men on the subject.

Railroads

By the mid 1800s, America was on the move, steel rails being king.





Progress wasn't flawless, however, as evidenced by the train wreck caused by an embankment failure on the Maryland and Pennsylvania line. As described in A History of York Township, 1753-2003, an "impressive accident ... creating quite a stir in Ben Roy." Locomotive No. 2 was badly damaged but repaired and returned to service.

The opinions of the railroad men regarding such matters -- we apologize for the gender exclusiveness, but this was the fact -- merit our pursuit.

We'll begin with five news accounts from the late 1840s.

As reported in "Growing over of Lakes," Michigan Farmer of January 1, 1849,

> *There is a small Lake, called Bear Lake, between here and Marshall, which is not far from half a mile across, and which is rapidly growing over. Mr. P. remarked, that during the seventeen years he had been in the country, more than one half of its entire surface had grown over, by means of the gradual accumulation of leaves and other decaying vegetable remains, which floated upon its surface, thus forming a productive marsh. This reminds us of the discovery of an underground lake by the Central Railroad Company, to their cost. A few miles West of Niles, they came to a marsh which needed to be raised to a grade of twenty feet. It is some seventy rods across it in the narrowest place, and here they commenced their grading, but they had not extended it more than forty feet from the bank, when the entire mass of earth, twenty feet in depth, which had been hauled upon the marsh, sank down and disappeared. Upon examination it was found, that the marsh, consisting of common muck, of some ten or twelve feet thickness, rested upon a lake, whose greatest depth is about eighty feet, and whose waters are clear as crystal. The marsh is about two miles long, and averages about a half a mile in width, covering doubtless through its whole extent, the waters of a once open lake. But the company were not to be daunted. They proceeded with their work, filling up where the grade had sunk, and extending it over the unbroken part, until another portion of it gave way, and thus they have gone on, filling up with earth from the bottom of the lake, until they have nearly completed the grade. Eighty men have been employed upon it for fifteen months, and for eight months of the time night and day, one set of hands relieving another. The expense has been enormous. The marsh has yielded the best of wild grass, and a portion of it is said to have been tilled, producing good crops of potatoes, corn, etc.*

The aerial photo to the right shows the location today, Brookwood Golf Course. We can only speculate if in some future era, historians will pursue correspondences between underground rivers and golf courses. See Chapter 81, East Side, West Side, All Around the Town, for further associations.

The Weekly Eagle, December 28, 1848, didn't explain much about the subterranean lake, other than its length, but we like the paper's use of the hand graphic.

> *A subterranean lake has been discovered on the line of the Central Railroad of Michigan. It was discovered by the sinking of the embankment built across a marsh plat of ground, and is ascertained to be about two miles in length, and in some parts half a mile wide.*

"Subterranean Lake Recovered," Scientific American, November 18, 1848, offered some speculation.

> *On the Michigan Railway it became necessary to carry a grading or embankment of fifteen feet high across a low piece of ground, containing about 100 acres, nearly dry enough for plowland. When they had progressed with the grading tor some distance, it became too heavy for the soil to support, the crust of the earth broke in, and the embankment sunk dawn into seventy nine feet of water! It appears that the piece of ground had been a lake, but had collected a soil of roots, peat, muck, &c., on its surface, apparently from ten to fifteen feet thick, which had became hardened and dry enough for farm purposes. Mr. Brooks thought it would have supported the road, and the fact might never have been discovered that it had rested on the bosom of a lake.*

"The Subterranean Lake on the Central Railroad, Michigan," Scientific American, December 30, 1848, provided a bit more detail.

> *In reference to this lake, which we noticed some time ago in the Scientific American, the Detroit Free Press says the sudden disappearance of the embankment was accompanied by tremendous convulsions of the ground for some distance around where the casualty occurred, and cracks were caused by the upheaving of the ground, deep and large enough to bury a cart and horse in. From exploration and researches made, it appears that the piece of ground over which the grading was to be made had once been a lake, but was not covered by a soil of roots, muck, &c. to the thickness of from ten to twelve feet. The submerged lake is about two miles long, and is in parts half a mile wide. At the place where this railroad track crosses, it is the narrowest. At one end of the lake is what appears to have been an island, as there are trees of large growth standing. The depth of the lake is ascertained to be about 80 feet in the deepest part.*
>
> *After the sinking of the first grading the work was pushed ahead with increased strength and for eight months, 80 hands were employed continually, day and night, one set retiring as the other came on to the work. As the embankment gradually extended out over the part that sank into the sod and crust, again it would become so heavy that another sinking would take place, and in this manner the work has been going on.*

"Subterranean Lake," Scientific American, April 29, 1848, reported much the same story in nearby Sandusky County, where we'll spend the entire next chapter, Mainlining the Sewage.

> *On the line of railroad between Sandusky and Urbana, and near Bellefontaine, Ohio, is a small "round prairie," containing about 80 acres. The Mud River Railroad was originally laid out and graded across this prairie, but the workmen one morning discovered that a portion of the track had disappeared; large timbers were laid across the "hole," and the superstructure again completed, when about six hundred feet of the road dropped down. Again the company sought to build a foundation -- the timber upon sixty acres was deposited, in this hole, and more than 10,000 dollars expended, and still the hole was not filled. A slight curve around the prairie was then made, at an expense of 1,100 dollars whereon the cars now run.*
>
> *Across this prairie runs a small stream -- the soil is rich, consisting of decayed vegetable matter, some six or eight feet in depth, which is evidently crust over a small lake; the water under this crust is thirty feet deep and fine fish are found in theses subterranean waters. The streams in this cave are not known to rise and fall with the waters of the Green River, in the vicinity, and is supposed to have a water communication with other lakes in the neighborhood, of which there are several, from the fact, among others, that the same species of fish are found in each.*

Three Scientific American stories in a single year make encrusted lakes a topic of national interest.

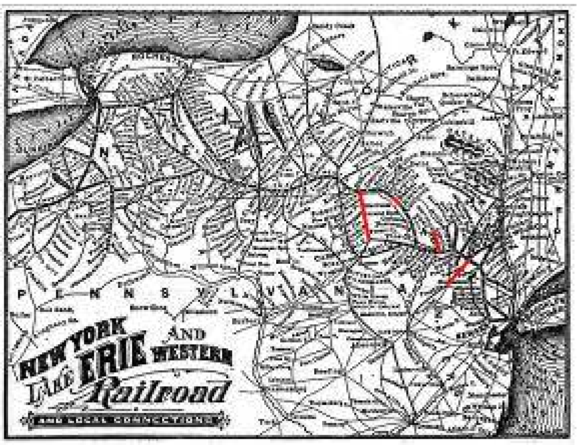
"Phenomenon in Indiana," Scientific American, September 23, 1868, kept the idea in popular circulation.

> *A portion of the track of the Bellefontaine and Indianapolis railroad, about 250 feet long, sank fully sixteen feet and the ground around sank with it. Traffic was interrupted until the track was raised by "cribbing." From twelve to eighteen inches appear where the water has risen out of the crack. A subterranean lake is supposed to exist under the track.*

And then there were the cases of New York, New Jersey and Pennsylvania railways.

The New York Times of September 5, 1871, and June 12, 1880, ("Rails in Unstable Spots, Building over Morasses and Underground Lakes, Instances where Portions of Roads Have Disappeared from Sight -- Driving Piles 160 Feet to Find Solid Ground -- Weeks of labor Made Useless in a Night -- A Train Sinking into the Ground") and the July 1892 Locomotive Engineers Journal chronicle a plethora of disappearing railway beds. Red marking on the 1884 railway map indicates the locations.

As the reports overlap, we'll combine the excerpts.



> *The Jefferson branch of the Erie Railway was built in 1812-8... When it was in course of construction the road-bed for a distance of a quarter of a mile disappeared one night. An apparently bottomless bog appeared in its place. Into this pit 10,000 cart-loads of gravel, and over 500 hundred hemlock trees, branches and all were thrown, without having any visible effect toward forming a bottom. A pile 40 feet long was then driven down its entire length. Upon it another one of the same length was placed and driven down, and still no bottom was found. Four of these long timbers were forced down, one on the other, before solid foundation was reached, proving that the bog, or lake, or sink, was 160 feet in depth. The existence of this*

> *curious formation at this spot was the more remarkable because it was on the summit of a ridge 2,000 feet above tide, and all around it were rocky hills and ledges.* -- New York Times, September 5, 1871

> *In 1870, when the Monticello and Port Jervis Railroad was being graded near Gilman's, it was noticed that the ground for several rods was moist and "shaky." It required much filling to make a solid road-bed. A year afterward, the road having been in operation several months, the watchman of that section of the track was walking along the railroad just after the passenger train to Monticello had passed the spot. Suddenly he saw the railroad embankment gradually sinking for a long distance ahead of him. He ran to a high bank at the side of the road just as the railroad dropped, with a loud noise, 15 feet below the surface. It required days of labor and the driving of long piles to construct a secure foundation for the rails*. -- New York Times, June 12, 1880

[We must briefly pause at this point to differentiate Monticellos. This one, the one having to sinking terrain, is in New York. The Monticello of the following December 13, 1890, New York Times underground-lake story is from Illinois.

> *Monticello -- Frank S. Brooks of Deland, Pratt County, has discovered an underground lake. He was digging a well on the farm of C.H. Moore, west of Deland, when he came to a strata of clay 15 feet thick so hard that he was compelled to use dynamite to remove it. After digging down 65 feet and boring 22 feet he came to a body of water, which burst forth with a rushing current and rose 50 feet in thirty minutes. It then was still rising.*

Following are two more railroad-meets-underground-lake items from the same paper.

> *Last fall one of these phenomena occurred near Basket Station, on the Erie Railway, in Sullivan County. About three acres of land, heavily timbered with hemlock occupying an elevated position, suddenly sank below the surface. The tops of the highest trees in the tract could not be seen above tee banks. The sinking was not accompanied by a crash, as in a landslide, but the land appeared to sink gradually and easily. The trees stood, and are still standing in their natural positions, as if nothing had occurred. In close proximity to the scene of this phenomenon there is a lake, which no doubt was once much larger, and over which this plot of ground had formed, as in the other cause.* -- New York Times, September 5, 1871

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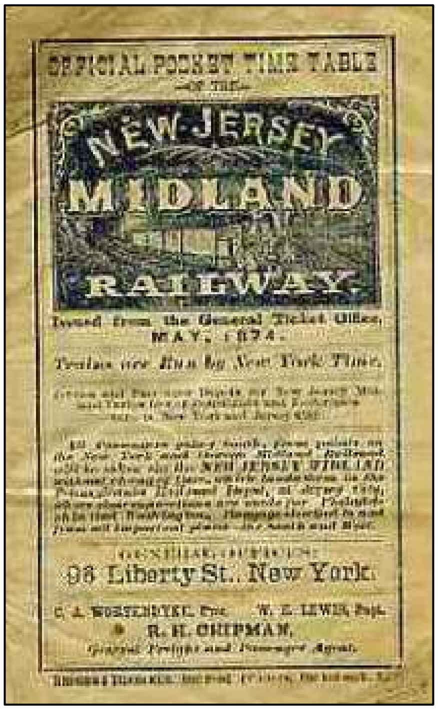


OFFICIAL POCKET TIME TABLE
OF THE
NEW-JERSEY
MIDLAND
RAILWAY.
Issued from the General Ticket Office,
MAY, 1874.
Trains are Run by New York Time.

GENERAL OFFICES:
98 Liberty St., New York.
C. A. WORTENDYKE, Pres. W. E. LEWIS, Supt.
R. H. CHIPMAN,
General Freight and Passenger Agent.

> *Near a point on the line of the New-Jersey Midland Railroad, known as Port Tuttle, the workmen were greatly surprised one morning a week or two since, to find that several rods of grading that they had left over night had entirely disappeared, and water and loose mud of unknown depth was all that could be seen. An iron rod fifty feet long was put down, but no bottom was reached, and its real depth hall not yet been ascertained. The general appearance of the surrounding country would seem to indicate that there is here an underground lake, which was once a natural sheet of water coveting a large area of country which is now a swamp. By the filling in for ages of earth and rooks from the hillsides, and the growth of vegetation, a crust has been formed over it, which has eventually closed the lake, and its surface is now entirely overgrown... To give foundation to the theory of a subterranean lake, fish have been caught and seen at these springs, from eight to ten inches all without eyes. They are in shape something like our common sucker. A portion of this swamp was once heavily timbered. A team passing over its surface will shake it for yards around, which gives strength to the surmise that it is floating ground.* -- New York Times, September 5, 1871

> *Bottom was finally found at a depth of 90 feet. As there was no thoroughfare for the road anywhere else in the vicinity, the gigantic task of making a substantial road-bed in the "Snufftown sink," as the pond was called, had to be accomplished or the railroad project abandoned*. -- Locomotive Engineers Journal, July 1892

> *An examination of the spot was made at the time of the sinking or the railroad grading by several scientific men, and they were or the opinion that the lake bad been incrusted by the accumulating vegetable matter of numberless ages until a surface had formed sufficient to sustain forest growth. The boiling springs were regarded as outlets to the subterranean lake.* -- New York Times, June 12, 1880

> *The phenomena of the incrustation of sheets of water, which, in the lapse of time, became solid earth apparently forms an interesting subject for scientific investigation. The process of this incrustation may be witnessed at Amber Lake, in the Town of Bethel, Sullivan County. A large of the shores of that delightful little sheet of water is a floating morass, which, near the water's edge, is too thin to sustain the weight of a grown person, but seems firm and solid as the shore is approached.* -- New York Times, June 12, 1880

> *The work of bridging over the waters' surface is going slowly on and doubtless continues, hence this entire lake will be encrusted like the ones already mentioned, and only to be detected as they have been.* -- New York Times, September 5, 1871

Today we're more familiar with Bethel, New York's earth-water issue as the muddy field of the 1969 Woodstock Festival.

In summary,

> *These singular lakes must prove of interest to scientific men and are worthy of earnest consideration.* -- New York Times, September 5, 1871

A bit to the north-east, the Whitehall and Plattsburg Railroad was having its own problems along Lake Champlain.

> *Another curious instance of this kind occurred in 1872 on the Whitehall and Plattsburgh Railroad, near Crown Point. A number of laborers were engaged in repairing the roadbed, gravel being brought to them by a locomotive and two flat cars. These cars had just been unloaded at the spot where the men were working, and, when the engineer started to return to the gravel pit, he noticed something wrong with the rails, and he discovered that they had moved several inches. He ran the train ahead, but had gone but a short distance when the roadbed, locomotive, train and all dropped suddenly 25 feet below the surrounding surface. The engineer and fireman were the only persons on the train, and they managed to clamber up one of the steep sides of the pit into which the train had been precipitated and reach the top in safety, and not a moment too soon, for both sides closed in on the locomotive and train, and they disappeared from view, half a minute later. The earth on all sides opened in fissures from four to eight feet wide and 50 feet deep, and the level surface of the ground for 400 feet around was changed into an area of rounded hummocks and cup-shaped hollows.* -- Locomotive Engineers Journal, July 1892

The New York Times of June 12, 1880, thought the disturbance somewhat longer.

> *The earth on all sides opened in large fissures, 4 to 6 feet wide and 50 feet deep, and the surface of the earth for 800 feet was changed into a series of hummocks and gullies*. --

And again to the west. From the Railway Age, November 1, 1901,

> *The Chicago, Indianapolis & Louisville has again experienced trouble with the sinking of a portion of its tracks in the vicinity of Cedar Lake, Ind. In the early part of July of the present year a portion of the track about 870 feet in length... was noticed to have settled several inches. A temporary spur was build around the old track and ballast was deposited into the depression on the main line. After being brought to grade a number of times, the track continued to settle until some 7,500 carloads of ballast and earth had been deposited into the depression, when a substantial roadbed was finally obtained.*
>
> *This experience... is a repetition of the difficulties contended with some four years ago, when the company made considerable improvements in the way of eliminating curves and grade on its line in Lake County. At this time, what appeared to be an underground lake developed in the new line of the road, and considerable material, together with a trestle work of piles was used before a substantial roadbed could be obtained.*

Unlike most reports of railways and underground lakes, the lake in Lake County "developed in the new line of the road," almost as if it came as response. One could conjecture that the water was impounded by, say, a the railroad's inadvertent damming of an underground river -- Indiana has such, as we're noted in earlier chapters -- but one could also wonder if the journalist was simply rushing to telegraph the scoop.

In all these cases, however, of sunken railroad beds, piles and fill were sufficient to bridge the obstruction.

Some railroads were more fortunate. From the New York Times, August 18, 1871, "A Subterranean Lake Beneath a Missouri Town,"

> *The first five feet of soil passed, the workmen came to a strata of red clay in which were imbedded masses of shattered flint. When this had been penetrated two feet, the pick disclosed a subterranean reservoir or water. The workmen abandoned the wall in alarm... when the sudden "falling out of the bottom" drove them to the surface.*
>
> *Some years ago a similar discovery was made... some few hundred yards* [away]. *Here the roof of the lake, composed of red clay and flint gravel, had fallen until only a thin crust remained. This was broken through by the hoof or a horse or cow, and the vapor arising one frosty morning attracted the attention of a colored man who reported it... White, waterless fish, identical with those found in Mammoth Cave in Kentucky, were seen and caught in buckets let down into the water. From these facts and others unnecessary to be stated, there must be a subterranean lake underlying the town of Newtonia.*

The 1888 map shows the route of the St. Louis and San Francisco Railroad, 8 kilometers north of Newonia. Successfully bypassing the alleged incrusted lake, the track was laid without problem, or so the railway men might have claimed.

NEWTON
Neosho

The skeptic might accuse the railway men of imaginations run amok by what was no more than profound mud, but as we noted early in our journey, were we to dismiss speculation regarding underground waters that seem nonsensical, what a short study this would be.

Rozel, Kansas was founded in 1886 on a two city block acquisition from the Atchison, Topeka & Santa Fe Railroad. Eleven years later, the periodical The Great Round World and What Is Going On In It, December 9, 1897, reported as follows:

> *A strange freak of nature is reported from Kansas.*
>
> *The railroad station of Rozel, eighteen miles from Larned, has been swallowed up.*
>
> *When the people in the neighborhood went to bed at night, the station was in its usual place; in the morning the station, two or three small elevators, and a few other small buildings had disappeared.*
>
> *Investigation proved that they had been swallowed up, and had disappeared in a chasm.*
>
> *The depth of this rent in the earth cannot be determined. The hole is said to be about an acre in extent, of oblong shape, with walls reaching straight down for seventy feet, at which depth the hole is filled with dark, stagnant water, into which anything that is thrown immediately sinks.*
>
> *No lives were lost, as no one remains at the station over night.*
>
> *The interest of the surrounding country is intense, and many theories are advanced as to the cause of the catastrophe.*
>
> *Some think that the station dropped into an immense cave, and others that it was caused by the underflow of the Arkansas River, which is overflowing its banks at the present time. Others think that this section of Kansas is over an immense underground river or sea.*

Rozel at the turn of the century boasted a bank, a mill, a grain elevator, a number of retail stores, telegraph and express offices; and a post office.

The 1900-1910 photo to the right identifies the depot, but shows no evidence of an acre-sized collapse, 70 feet in depth.

Union Grain Co.
Depot

The truth is that not much happens in Rozel. Population in 1910 was about 200, and today it's closer to 170. Perhaps The Great Round World reporter was conglomerating stories of sinkholes, knowledge of the Ogallala aquifer, railway lore and the foundation failure of a hastily-constructed edifice.

Railway officials were duly thankful for the sun-bonneted lass, reported Outlook, September 7, 1895, whose diligence thwarted the malfeasance of the underground stream.

> *A Brave Little Girl. A little girl was picking berries recently near the track of one of the Western railroads. A locomotive with one car, having some officials of the road on board, passed rapidly. Almost as soon as the special train had passed, the little girl saw twenty feet of the track sink out of sight. She knew a regular train would soon pass, and, dropping her berries, she ran past the bend and waved her sun bonnet when the train came in sight. The engineer stopped the train. The little girl told the man what had happened. The trainmen went forward and found that an underground stream had undermined the track for quite a distance. The passengers would have been hurt and probably some would have been killed but for the presence of mind of this little girl.*

"Road Commissioners Waste $900 in Dirt on Bottomless Hole," Daily Illini, January 31, 1924, reported a road-building difficulty from Sheridan, Michigan

> *The county road commissioners have found a "bottomless hole" a short distance west of this city. At least, they have decided that the sink hole that have been trying to fill up has nor bottom, for after spending $900 buying dirt to fill in the hole they have been compelled to survey a new route around it. The $900 worth of dirt disappeared and the sink hole seems to be no nearer full than when the work started. It is considered likely that the great hole is an opening to an underground river and that the dirt is washing out.*

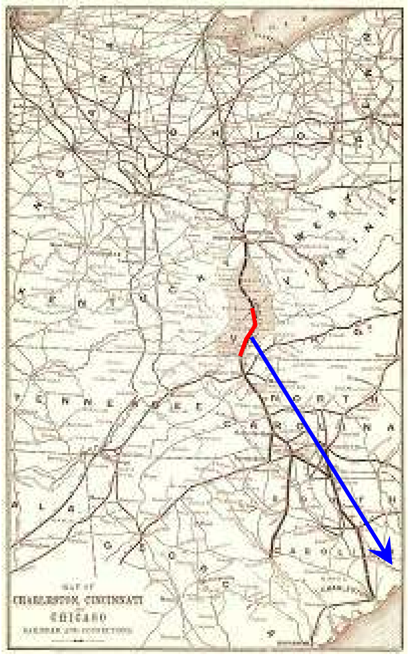
This one's an automobile road, not a railroad, of course, but the problem's much the same.

And not all railroad stories even make sense. "Farmer's Department, A Supposed Subterranean River," New York Evangelist, November 8, 1888, relates a rail-line "discovery" to the south.

> *A telegram from Charleston... says that a discovery which indicated the existence of a subterranean river running from the mountains of Virginia through North and South Carolina has been noted in these dispatches. Recent additional discoveries seem to confirm this theory...*
>
> *At Black's, two farmers were digging a well on their farm, which is on the line of the Charleston, Cincinnati and Chicago Railroad... At a depth of twenty feet they struck a limestone formation which gave out a hollow sound. A few feet of the stone was removed and a workman striking the point of a bar into the seam of the rock was surprised -- first, to see a hole open him and then to see his bar disappear from sight. The rush of air following this break through the roof of*

> *the cave or cavern was accompanied by a loud noise, which continued into the next day... Later the depth of the hole was attempted to be measured by the use of a long pole, but it failed to reach anything solid, and when dropped gave back no sound to those who listened.*

The red line on the 1889 map indicates possible locations of the well "on the line of the Charleston, Cincinnati and Chicago Railroad." The blue illustrates the suggested underground route.



The story was carried in the Atlanta Constitution of October 25, 1888, adding,

> *It is remembered that a well dug upon the northwest side of Whittaker Mountain, some years ago, was abandoned for the same reason, the discovery of a large cavern without apparent bottom. Parties familiar with the rock formation of this section say they are probable openings into one of the same hollow places extending under ant through the mountain. Whether this is a mammoth cave or subterranean river remains to be proven. An investigation will be had at once.*

The story from Virginia seems reasonably likely, as the west end of the state has numerous karst formations. And the South Carolina coastal zone indeed has sinkholes. As the Carolinas are otherwise sparse in karst geology, however, --North Carolina has but one major cave and South Carolina, none -- the Evangelist title's "Supposed" reflects the actuality

Severed Drainageways?

Surely a portion of the railroad's hydrologic misfortunes stemmed from the speed of railway expansion. Rivers were to be crossed, mountains tunneled and marshes made dry. While Farm Drainage, The Principles, Processes, and Effects of Draining Land with Stones, Wood, Plows, and Open Ditches, and Especially with Tiles (1860) by Henry Flagg French wasn't about railroading, even French recognized the implication.

> *The water falling on the surface would very slowly find its way downward, at first. But after the heat of Summer, aided by the drains underneath, had contracted and cracked the soil, passages for the water would soon be found, and, after a few years, the whole mass, to the depth of the drains, would become open and permeable. As an old English farmer said of his drains, "They do better year by year; the water gets a habit of coming to them." Although this be not philosophical language, yet the fact is correctly stated. Water tends towards the lowest openings. A deep well often diverts the underground stream from a shallower well, and lays it dry. A single railroad cut sometimes draws off the supply of water from a whole neighborhood. Passages thus formed are enlarged by the pressure of the water, and new ones are opened by the causes already suggested.*

The railroads were indeed major forces, but the force of water was greater.

Incrustation?

Nathaniel Langford, the first Superintendent of Yellowstone National Park may have had something to do with the railroad builder's thinking. The Discovery of Yellowstone Park wasn't published until 1905, but as Langford had been promoting the national-park-to-be since 1870, the explorer's observations were in broad circulation.

> *Around them all* [the hot springs] *is an incrustation formed from the bases of the spring deposits, arsenic, alum, sulphur, etc. This incrustation is sufficiently strong in many places to bear the weight of a man, but more frequently it gave way.*

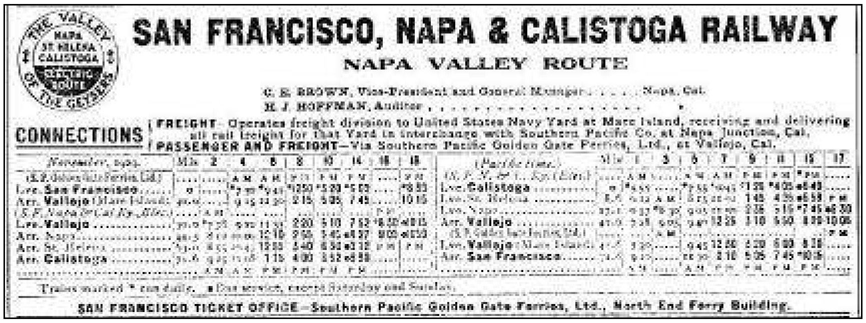
While Langford's "incrustation" was a sulfurous matrix incapable of vegetation, nothing resembling the terrain perplexing the railway builders, it seems possible that Langford's work provided the engineers a hypothesis about their own challenge.

Geological incrustation might be considered as the underground river process in reverse. In the former, a surface comes to be above the fluid. In the latter, water tunnels its way beneath that which is the solid. In either case, resulting order of strata is somewhat the same.

Others have employed the crust allusion elsewhere.

Robert Louis Stevenson linked railroads and encrusted lakes with just a passing reference The Silverado Squatters (1906) Calistoga, California travelogue.

> *The whole neighborhood of Mount Saint Helena is full of sulphur and of boiling springs. The Geysers are famous; they were the great health resort of the Indians before the coming of the whites. Lake County is dotted with spas; Hot Springs and White Sulphur Springs are the names of two stations on the Napa Valley railroad; and Calistoga itself seems to repose on a mere film above a boiling, subterranean lake.*



SAN FRANCISCO, NAPA & CALISTOGA RAILWAY

NAPA VALLEY ROUTE

C. E. BROWN, Vice-President and General Manager . . . . . Napa, Cal.
H. J. HOFFMAN, Auditor . . . . "

CONNECTIONS FREIGHT—Operates freight division to United States Navy Yard at Mare Island, receiving and delivering all rail freight for that Yard in interchange with Southern Pacific Co. at Napa Junction, Cal. PASSENGER AND FREIGHT—Via Southern Pacific Golden Gate Ferries, Ltd., at Vallejo, Cal.

SAN FRANCISCO TICKET OFFICE—Southern Pacific Golden Gate Ferries, Ltd., North End Ferry Building.

Fortunate for the San Francisco, Napa & Calistoga crew, the engine didn't break through the "mere film."

We of the Never-Never (1908) is an autobiographical novel by Jeannie Gunn, an account of the author's experiences in Australia's Northern Territory.

> *It is in appearance only the pools are isolated; for although many feet apart in some instances, they are linked together throughout by a shallow underground river, that runs over a rocky bed; while the turf, that looks so solid in many places, is barely a two-foot crust arched over five or six feet of space and water -- a deathtrap for heavy cattle; but a place of interest to white folk.*
>
> *The Maluka and I wandered aimlessly in and out among the pools for a while, and, then coming out unexpectedly from a piece of bush, found ourselves face to face with a sight that froze all movement out of us for a moment -- the living, moving head of a horse,... a grey, uncanny, bodyless head, nickering piteously at us as it stood on the turf at our feet. I have never seen a ghost, but I know exactly how I will feel if ever I do.*
>
> *For a moment we stood spellbound with horror, and the next, realizing what had happened, were kneeling down beside the piteous head. The thin crust of earth had given way beneath the animal's hindquarters as it grazed over the turf, and before it could recover itself it had slipped bodily through the hole thus formed, and was standing on the rocky bed of the underground river, with its head only in the upper air.*

In an era of accolade for robber barons, the highest praise for a railroad tycoon could be that of conquering an incrusted lake. From "A Study of Harriman, Master of Railroads, and his Methods of Work," New York Times, August 1, 1909,

> *The best illustration of Mr. Harriman's constructive gift is not so much the plan of the Lucin cut off, involving the construction of a viaduct across the Great Salt lake, as the fact that Mr. Harriman ventured where other railroad managers had only sighed and hoped. He dared to sink millions in the then unmeasured abyss of that salt sea, never wavering, not believing that he was throwing good money after bad, fighting constantly against nature, until at last, having sunk some thirty million in those incrusted waters, he conquered nature, stretched his viaduct across the sea, and was able to reckon that the saving in time and cost far more than met the interest upon the cost of this investment.*

The correspondent for Scientific American, November 16, 1867, wasn't much impressed by the citizens of Milan,

> *The inhabitants are generally slovenly, listless, lounging set, who appear to vegetate in a condition of dreamy unconcern about the present or the future.*

But more to our point.

> *We were informed that several months before the roadway that led across the spur of the mountain suddenly sank beneath the water, carrying with it a portion of the village, together with several of the inhabitants, who were hopelessly engulfed in this subterranean stream, which for ages had been gradually wearing away under the crust of the mountain.*

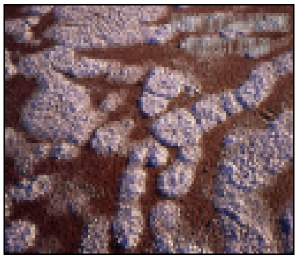
Perhaps the Milanese were disconsolate because of their geological precariousness. Could such fluvial "wearing down of the crust" have been likewise vexing the American railways?

Unfortunately we must conclude that encrustation's geotechnical aspects indicate to the contrary.

Geothermal-derived incrustations -- which yet may be readily seen in Yellowstone -- are sterile surfaces, far different from the forests of eastern railroad right-of-ways.

Mineral incrustations are brittle, shattering, rather than deformational.

Organic incrustation -- though "incrustation" isn't quite the word, as the mat wouldn't be crusty -- would be planar, pliable and capped with aquatic flora. A surveyor proceeding forward would have found himself wading and more solid route immediately scouted.



No, we must conclude, the railroads weren't intruding onto a crust.

Floating Islands?

We see several accounts' use of "floating islands," like "encrustation," another terminology of the times. Might the pesky underground lakes have been topped by floating islands?

The idea of buoyant earth wasn't a new thought. The Babylonian deity Marduk (Chapter 1) was said to have heaped dirt on a rush mat floating on the universal primordial water. Roman Encyclopedist Pliny the Elder (Chapter 3) mentioned islands floating in Lake Vadimo, site of the battle between Rome and the Etruscans. Athanasius Kircher (Chapter 8, Subterranean Engines) described similar islands, the "sixteen little boats" in Lago della Regina.

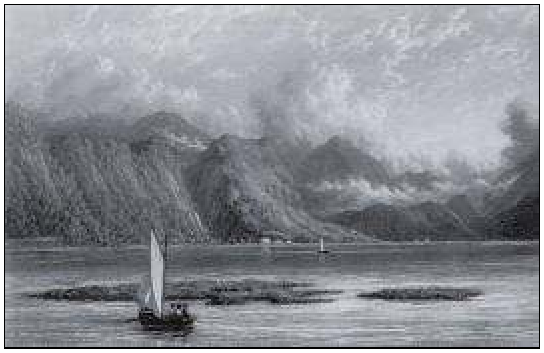
And more floating islands were yet being reported.

Thomas Milner's 1882 tour-de-force in natural theology (Chapter 8) -- a pious pursuit we thought long abandoned by his day -- described Italy's Lake Vadimo.

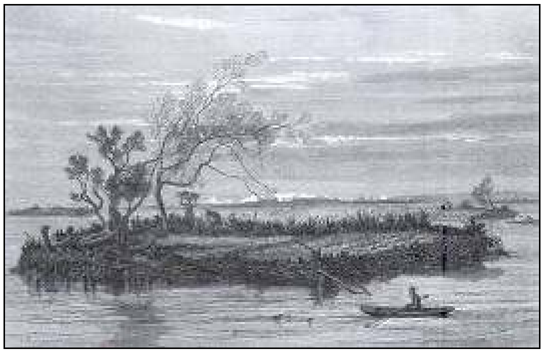
> *Several floating islands swim about in it, covered with reeds and rushes, together with other plants, which the neighboring marsh and the borders of the lake produce. These islands differ in their size and shape; but the edges of all of them are worn away by their frequent collision against the shore and each other. They have all of them the same height and motion, and their respective roots, which are formed like the keel of a boat, may be seen hanging down in the water, on whichever side you stand. Sometimes they move in a cluster, and seem to form one entire little continent; sometimes they are dispersed into different quarters by the winds; at other times, when it is calm, they float up and down separately. You may frequently see one of the larger islands sailing along with a lesser joined to it, like a ship with its long-boat; or, perhaps, seeming to strive which shall out-swim the other; then again they all assemble in one station, and afterwards joining themselves to the shore, sometimes on one side and some times on the other, cause the lake to appear considerably less, till at last uniting in the centre, they restore it to its usual size.*

Perhaps more to the interest of Americans, Milner goes on to describe a log island, 16 kilometers in length, at the mouth of the Mississippi.

> *The great raft near the mouth of the Mississippi is a production of an analogous kind. This is composed of the wood annually drifted down that river and its tributaries, consisting of the magnificent trees growing upon their banks, which fall into the waters, owing to the floods undermining their foundations and loosening their roots. Arrested by some obstruction in the river, a mass of timber has thus accumulated, and become consolidated by the interlacing of weeds and the deposition of alluvium, so as to form what is called "the raft," the dimensions of which in 1816 amounted to a length of 10 miles, a width of 220 yards, and a depth of 8 feet. This is an island afloat in the bosom of the waters, having externally the appearance of solid land, for green bushes and a variety of beautiful flowers bloom upon its surface.*

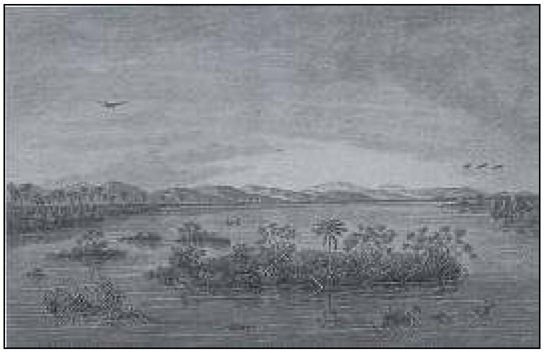


W. Westfall, Floating Island in Derwentwater (1821)



Jardins Flottants au Mexique (1878), a fanciful depiction by Jean A.V. Foulquier

As might be surmised from these several engravings, the lettered public of the day (which would have included those schooled in railway engineering) would have been aware of marvelous floating islands.



Floating islands along the Congo River encountered by the de Brazza expedition of 1879-1882 in Paul Bory's Les Explorateurs de l'Afrique (1890)

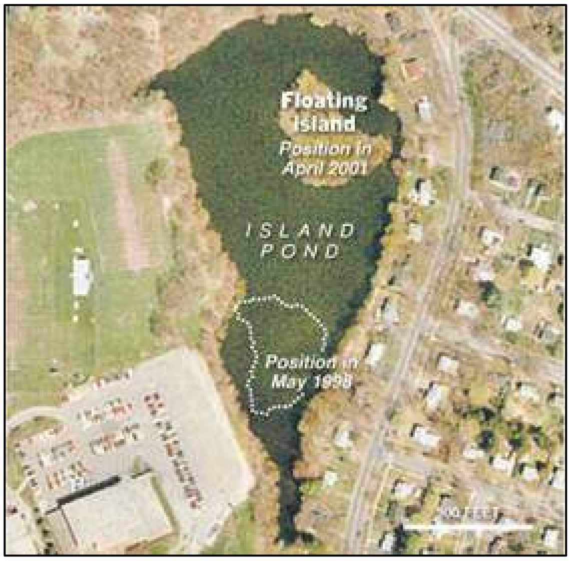
The concept of land floating upon water was thus not unfamiliar to those marching America westward.

Nor is land over water unfamiliar to scientists of today.

"Floating islands," also referred to as "tussocks," "floatons," "floating bogs" or "sudds," are buoyant mats of aquatic plants, peaty soil, sphagnum moss and organic detritus ranging in thickness from a few centimeters to two meters and can be as large as several hectares. Floating islands typically originate along lake shores when growths of cattails, bulrush, sedge and reeds extend outward from the shoreline. Decomposing vegetation releases gases that create buoyancy. When storm events tear sections free from the shore, the islands thus formed are blown about the waterbody, eventually either reattaching to the shore or breaking up. Examples are illustrated below.

A noted floating island is the football-field-sized eponymous mass in Massachusetts' Island Pond. Its 3-meter birches, alders and pines serve as sails, ferrying the island across the pond in as little as 20 minutes. An aerial photo is shown to the right.

Traversing the island is said to be like "walking on a waterbed."



Floating islands are also found in

The Yucatan cenote Zacatón (Chapter 40), 3 to 10 meters in diameter
Lake Titicaca, reed mats, some human-constructed
Lake Kyoga, Uganda
Lake Loktak, India
Lake Umbagog, Maine
Lake Visitor, Montenegro
Lakes Gerdau and Kolk, Germany
Lake Vlasina, Serbia
Lake Upemba, the Congo
Lake Chad, north-central Africa
Lake Finicha'a, Ethiopia

Riverine floating islands form where flooding tears away chunks of tropical river bank. Most are broken up, but some are more durable.

In 1902, the Norwegian ship Donald, steaming from Cuba to Philadelphia, encountered a floating island having coconut palms growing on it, complete with monkeys. The next day the Donald encountered another floating island having palm trees filled with parrots.

In 1908, a United States cruiser north of Honduras encountered a floating island one kilometer in circumference with dense bushes, vines and three coconut palms in the middle.

So, yes, the floating island tales stemming from Pliny and Kircher have basis in fact.

But were floating islands the geotechnical bane of American railroads?

Of course not.

Geophysical surveys (Chapter 46, Finding the Underground Rivers) reveal no cases where floating solids coalesce to match the visual aspect of their containment.

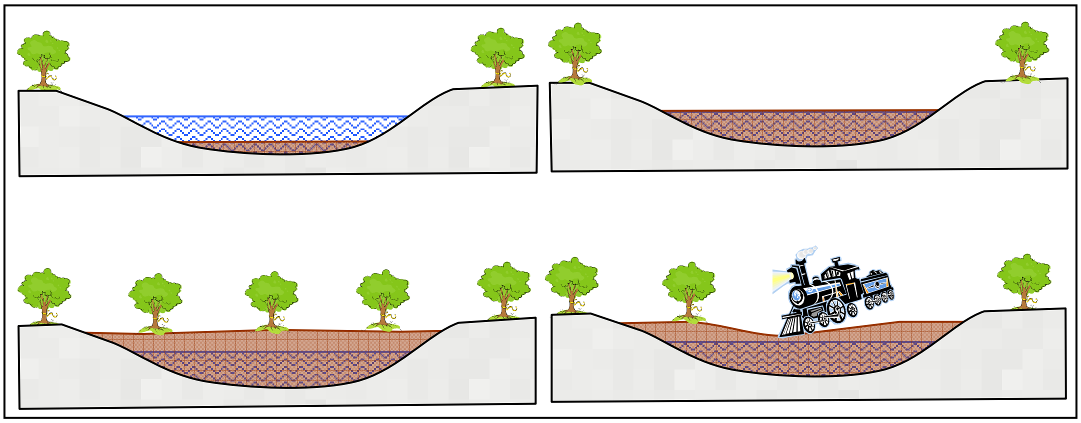
Several meters (the observed record being no more than three) of buoyant biomass would appreciably sag under the weight of walking men, not wait until the railroad bed was laid upon it.

Detritus would settle to the bottom, converting what was once free water into a solidifying bog, and with further compaction, organic soil.

In Floating Islands, a Global Bibliography (2004), Chet Van Duzer catalogs 135 United States lakes with floating islands, 80 of which are in states admitted to the Union before 1840. Van Duzer cites no instances of attempted rail construction over such formations.

Few, if any, American railroad builders had ever encountered, casually or professionally, rivers under earth or land upon lakes, but the engineers' imaginations were ripe for such possibilities when their tasks encountered difficulties. Alas, we must conclude, manifest destiny was impeded by neither friable crust nor floating islands, but indeed they were occasionally blamed.

American railroading was occasionally behind schedule, but rarely for long, and not due to hidden waters. The culprit was nothing more than bogs.

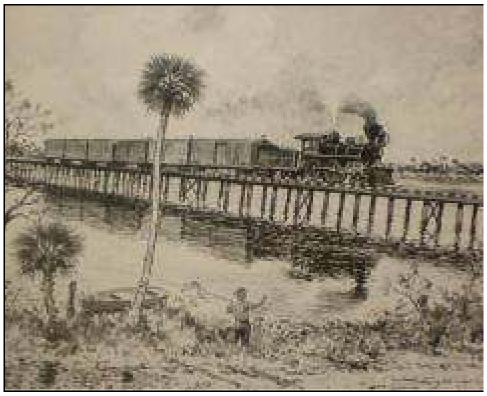


The following account, "A Lost Lake," McKean [Pennsylvania] Democrat, October 30, 1891, would be more correctly classified as a sinkhole story than as one dealing with an encrusted lake, but we'll put it here, as it's also about railroads.

> *A curious spectacle was to be seen on the outskirts of Gainesville, Fla., recently. Alachua lake, from ten to fifteen miles in length and covering more than 40,000 acres of land, is no more... This was the second time since 1823 that a similar occurrence has taken place. At that time the bed of the lake was a large prairie -- Payne's prairie -- having in it a body of water called the Sink and a small creek. In 1868 heavy rains filled the prairie, but the water disappeared after a short time, and the prairie was again dry land. In 1873, after a series of heavy rains, the Sink overflowed and the creek swelled to the dimensions of a lake. During several years the waters increased till a larger lake was formed, and for fully fifteen years sufficient depth of water stood over the prairie to allow small steamers. During the last two years, however, the waters have been gradually lowering, and about four weeks ago they commenced going down with surprising rapidity, the lake falling about eight feet in ten days, until now there is nothing left of Alachua lake but the memory of it. There is evidently an underground passage connected, and for some reason not understood, this underground passage has been acting as a drain until all the water in the lake has been drawn out.*

In 1871 the sink was plugged with logs and debris and so Paynes Prairie became the Alachua Lake, plied by low-draft steamboats like the "Cicola" which shipped citrus. In 1892 the sink became unplugged and rapidly drained, once again reverting to its prairie state.

Below and to the left is an 1890s painting by James Calvert Smith of the railroad trestle skirting part of Alachua Lake. To the right is a photo of the drained waterbody.



A Brave Engineer and the Report of a Doctor

Before we leave our railroading, we'll include an inspirational story, one set at no less than River Styx, Ohio, a stop we made in Chapter 55, A Superfluity of Surficial Stygian Streams.

On March 22, 1899, Engineer Alexander Logan ran Train No. 5 along the Erie Line near the River Styx, traveling at some 130 kilometers/hour. The engine mysteriously jumped its tracks, turned over and crushed the engineer to death. No one knew what caused the train to derail, but most agreed that Logan's heroic decision to stay on the train saved the lives of the crew. Witnesses said that when Logan's body was recovered, his hand was still clutched to the throttle.

The River Styx Bridge is shown to the right.

On November 8 of that same year, the Wooster Republican reported.

> *A Phantom Train, Uncanny Happenings Reported from Rittman.*
>
> *Word has been received here that several Rittman people have seen a phantom train at the River Styx bridge on the Erie Railroad. The first appearance of this awe-inspiring train was last week, Saturday night and was witnessed by Dr. Wm. Faber, coroner of Wayne County, and a companion.*
>
> *The doctor had been to see a sick patient and was driving leisurely along about 11 o'clock, when his attention was attracted by the noise of a swiftly moving train. He casually watched the train and saw its glaring headlight and dense clouds of smoke rolling up from the smokestack. He paid no more attention to the train, but just before it reached the bridge the shrill whistle of the engine calling for brakes caused for the men to glance back. On came the train with the speed of a whirlwind as it swept down the grade, throwing out great sparks of fire from the wheels. Just then they heard the "chuck chuck" of the engine, as it had been reversed, and the escaping of the air of the air-brakes. Then a strange sight met their gaze as they sat spellbound. The train was enveloped in flames which shot up the escaping steam making a terrific noise, and the cracking of timber and breaking of iron bars was plainly heard, but above*

> *all came the piercing shrieks of human beings pinned beneath the wreckage. The noise was plainly heard by a number of others.*
>
> *The Doctor and his companion started immediately for the place of the wreck for the purpose of rendering assistance, but to their surprise they found every thing perfectly quiet and no sign of a wrecked train.*
>
> *Near this spot the ill-fated train No 5 jumped the track last spring, and the engineer was killed, ever since that time many people have believed that the place is haunted.*

This isn't to say that we believe the gentlemen, but we advise caution when railroading near underground waters.

CHAPTER 75

MAINLINING THE SEWAGE

We will leave to environmental historians the stories of toxic wastes dumped on sites erroneously assumed to be disconnected to subsurface waters. We will deal in this chapter with a less-excusable environmental practice, that of deliberately mainlining raw domestic waste directly into the most convenient waterway, a river below.

Our story is set in Bellevue, Ohio, a middle-American small city, where they still remember their "Whiz Kids," the 1945 State of Ohio basketball champs.

BELLEVUE, OHIO.
SANDUSKY & HURON COUNTIES.

As described by the 1918 Encyclopedia Americana,

> *Bellevue, Ohio, city in Sandusky County, on the Lake Shore and Michigan Southern, the New York, Chicago and Saint Lewis, the Lake Shore Electric and other railroads, about 16 miles south of Sandusky. It contains a Carnegie library and a hospital and has railroad repair shops, canning factories, lumber yards, manufactories of agricultural and drainage machinery, fixtures and stoves. It is the trade center for a thriving agricultural region.*

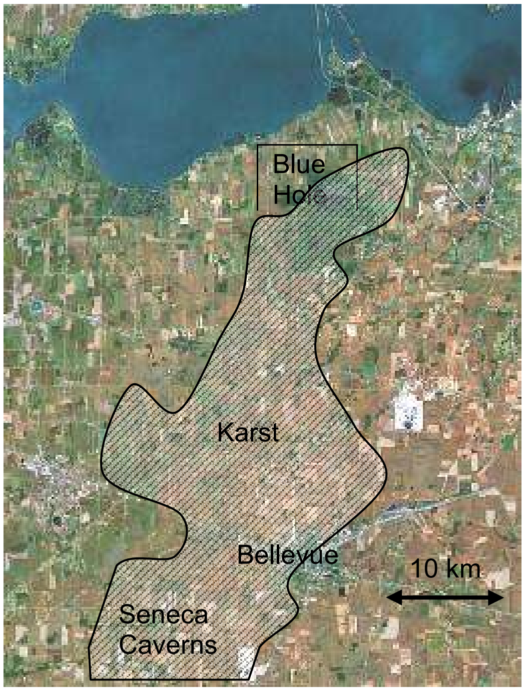
We'll quote the remainder of the entry later in this chapter.

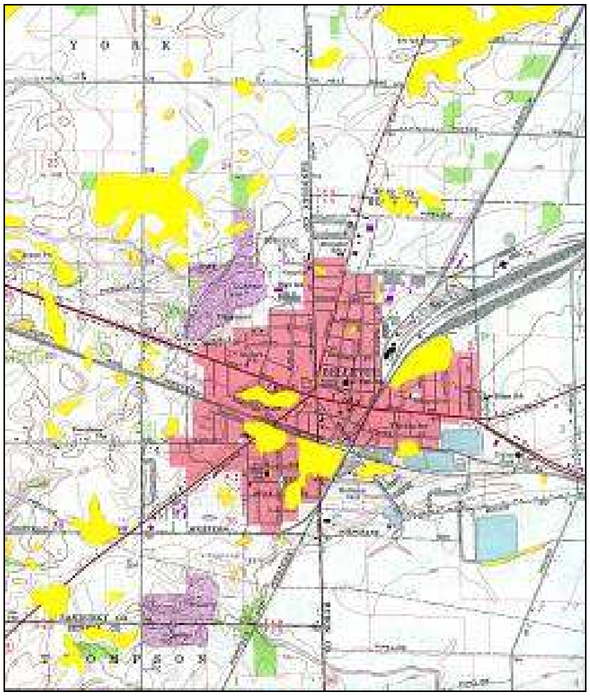
Hydrogeology

The Bellevue-Castalia Karst Plain bordering Lake Erie is underlain by up to 55 meters of Devonian carbonates. Surficial karstification characteristics are slight where the limestone is overlain by deep glacial drift.

Near the City of Bellevue area, however, the glacial till is commonly less than 6 meters deep or not present at all and surface water has more opportunity to rapidly intrude into the limestone.

The landscape is marked by irregularly shaped, closed depressions of up to 110 hectares which in turn encompass smaller, circular depressions 2 to 25 metes in diameter, of which there are more than 1,000. Surface drainage is limited and many of the streams disappear into such sinkholes.





The yellow overlay on the U.S.G.S. quadrangle represent closed basins, topography without external drainage. These zones rarely have standing water, however, because the subdrainage is not overtaxed by normal rainfall events. Such depressions within the urban area are drained by storm sewers.

South of Bellevue lies Seneca Caverns, discovered in 1872, the self-proclaimed "Caviest Cave in the USA." Colorfully illuminated "Ole' Mist'ry River" runs through the lowest cavern, 35 meters below the surface.

Seneca Caverns
$14.00

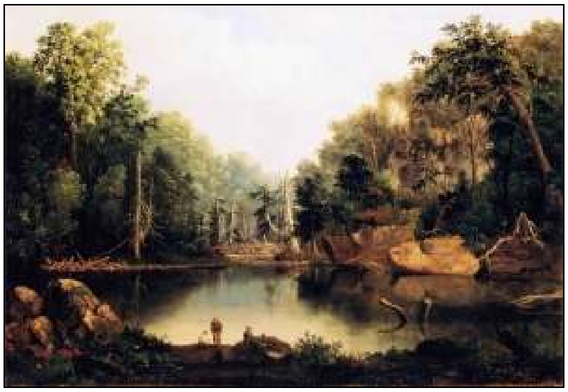
A like-named Seneca Caverns located in West Virginia is that state's largest cave and has on display a biscuit tin from its days as a fallout shelter. Both Seneca Caverns boast gift shops. One would think that there were enough cavern names to go around.

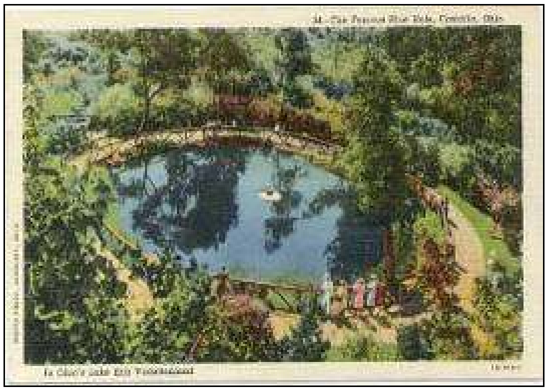
But even before 1872, the area was known to contain subterranean rivers. As chronicled by Henry Howe in Historical Collections of Ohio, Containing a Collection of the Most Interesting Facts, Traditions, Biographical Sketches, Anecdotes, Etc. (1851), just a kilometer or two south of the soon-to-be-discovered caverns,

> *In the township of Thompson, is a subterranean stream, about 80 feet underground. The water is pure and cold, runs uniformly, and in a northern direction. It is entered by a hole in the top, into which the curious can descend on foot, by the aid of a light.*

North of Bellevue is a tourist attraction of bygone decades, the Blue Hole. Blue Hole came into being about 1820 when pressure caused by damming Castalia Creek weakened the strata and occasioned its collapse. A subsequent cave-in left the hole roughly 25 meters in diameter. Contrary to prevalent belief, the depth is not unknown; it's 15 meters. Discharge is about 0.3 cubic meters/second of crustal clear water.

African American artist Robert S. Duncanson painted portraits, landscapes and murals. His 1851, “Blue Hole, Little Miami River,” is shown to the left. A 1920s postcard is to the right.

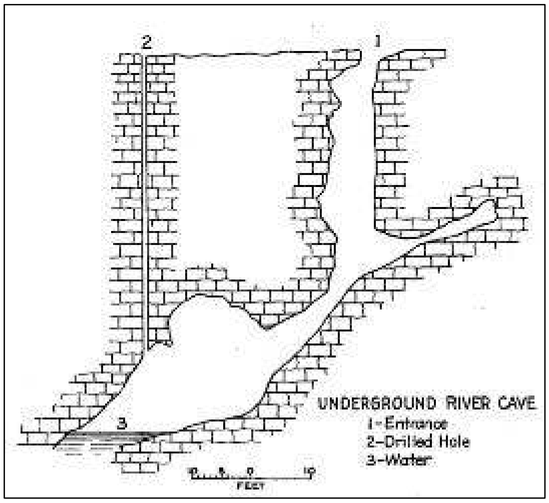




In 1997, the Ohio Department of Natural Resources Division of Wildlife purchased the site, re-naming it the Castalia State Fish Hatchery.

While the cavern itself isn't particularly noteworthy, we cite "Underground River Cave," Limestone Caves and Caverns of Ohio (1873), Geological Survey of Ohio, by George W. White, for the description of its water.

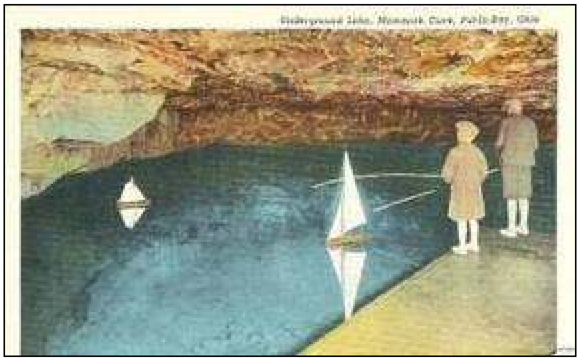
> *Underground River Cave is in the northern part of Ridge Township, northwestern Wyandot County.*
>
> *No groundwater drains into the cave, but the surface of the water in it fluctuates as much as 31 feet. When visited it was 65 feet from the exterior surface, but during the winter it is reported to fall at least 20 feet below this. Many stories exist as to the depth of the water. The owner states that when it reaches the lowest mark there is a current which flows eight to ten miles an hour. It is popularly supposed that this stream comes to the surface in the Blue Hole at Castalia, 44 miles distant, but this seems improbable.*



> *This cave is lighted by electricity and plank steps lead to the water. A commodious rest house stands over the entrance. A hole has been drilled from the surface of the ground to the water in the cave which serves for ventilation and is occasionally used to mystify visitors by having someone talk from the surface to tourists below. A fee of 40 cents is charged for admission.*

While it's surely a far-fetched hydrologic connection, Put-in-Bay, 20 kilometers north of Sandusky on Lake Erie's South Bass Island, has its own "Underground Lake," postcard pictures below.

The lake in the Daussa's Cave, Put in Bay, O.



Who's to say the region's mysterious underground stops at the lake shore? From Science Weekly, December 2, 1904,

> *The caves of Put-in-Bay have been long known to the public, but, with the exception of Mr. E.L. Mosely, no one seems to have discussed the evidences which they present as to recent changes of lake level. Daussa's Cave is probably the one which Mosely visited. In this cave there is an underground lake 80 feet long and 40 feet wide, which is connected with and fluctuates with the waters of Lake Erie.*

As to what connects with what in the region, there's been no end to the speculation. From the Marietta Daily Leader, May 10, 1897,

> *A subterranean channel connecting with the immense cave recently discovered in Seneca and adjoining counties is believed to exist in the south-eastern portion of this [Sandusky] county. At least an underground stream has been discovered on the Ensminger farm. The bottom dropped out from two wells dug about 30 feet deep on the Ensminger farm. An underground river was discovered that is eight feet deep and no one knows how wide. Eyeless fish were taken from the stream, which flows to the north, and is thought to connect with the Flat Rock [Seneca] cave.*

The Federal Writers' Project Ohio: The Ohio Guide (1940) had this to say,

> *Left from Bellevue on State 18 ... are Seneca Caverns (open Decoration Day to Labor Day, adm. 57¢ -- $1.13), 4.5 m. These eight electrically lighted, located at different levels, have been produced by the slow action of water working in limestone strata. Hewn-rock steps lead to the lowest cavern, 165 feet down, through which flows an underground stream. A bottle thrown into it in 1930 was cast up in 1934 at Blue Hole, 15 miles away.*

Regarding the bottle, however, we should remember that the Federal Writers' mission was to record America's stories, not to fact-check them. Fifteen miles in four years is 0.7 meters/hour, an achievable velocity through a karst conduit. While the probability would seem small for the jar not not becoming wedged in a constriction, the legend falls well within the spectrum of underground river flotsam reports we've encountered in other chapters.

As an aside, we should note one additional geologic curiosity. In Memories of the Lakes Told in Story and Picture (1946), Dana Bowen writes of the risings and sinkings of Split Island in Sandusky Bay. Floating islands (our previous chapter) and underground rivers indeed seem to have affinity, one with the other.

"Find an Underground River. Further Evidence of Mighty Stream Coursing Through Ohio" in the August 22, 1901, Syracuse Daily Journal saw a likely subterranean connection between Marion and Cleveland Ohio.

> *Roaring wells in widely separated parts of the State indicate the existence of a mighty subterranean river that flows across the State at a depth of comparatively few feet below the*

> *surface, at least in certain places. The latest of the roaring wells is at Chardon, a suburb of Cleveland. The men have refused to work on it and plans are being made to dynamite it.*
>
> *The phenomena are exactly the same as those noticed in a well on the farm of Mrs. Amanda Ensminger hear here. When this well had been dug to a depth of about 50 feet, the roaring noise became alarming, and during the night the bottom fell out and left an opening into the subterranean stream that was so swift that it was impossible to sound it.*
>
> *The wells at Chardon are evidently on the same underground river, for the phenomena are identical and indicate that the mighty unseen river extends across the State from north to south.*

As Cleveland is some 100 kilometers east of Bellevue and Chardon is yet further, it seems unlikely that it's the same underground river, however. We do note that by removing one letter, "Chardon" becomes "Charon," but we refrain from claiming the fact to be significant.

Flooding from Below

We will begin our chronicle of Bellevue flooding with the New York Times story of December 6, 1891.

> *Lake Formed in a Night. The Subterranean River which Sends its Water to Lake Erie*
>
> *Cleveland, Ohio, December 4 -- Flowing into Sandusky Bay, one of the most beautiful landlocked bodies of water in the United States, is a stream called Castalia Creek. It is fed from springs of ice-cold water. This creek has been utilized by a fishing club and stocked with brook trout. It is without doubt the most complete private fishing preserve in the United States, and the great catches made by successive anglers have often been given in publications devoted to out-door sports.*
>
> *Whence comes the water which supplies these springs is a mystery.*

"Whence comes the water" waxes poetic, but the whence is no mystery to those acquainted with with geology. We'll read on, noting how personal story enlivens journalism.

> *That such an underground stream does exist there is no question. In going over some places the other day an interesting document signed by T.C. McGee, an old resident of Erie County, was discovered.*
>
> *"My father, Thomas McGee," the old resident wrote, "came to the State of Ohio in 1818. While waiting for the Indian lands to be surveyed and come into the market he made a temporary stop in a vacant house in the southwest corner of Groton Township, Erie County. Near the house was quite a large prairie. My father planted about two acres with corn. About the 10th of June that year, when the corn was some three inches high, on getting up one morning to go and put some fencing about his field, he looked where the field had been, and found a lake covering it and nearly all the depression in the land near it. He had heard nothing, but a neighbor who lived nearer the spot of land had heard in the night a loud but dull sound.*
>
> *"My oldest brother, William, who always wished to know the reason of things, with my help, built a raft out of the floating rails and went out and over where the water was boiling up with great force from a space as large as a fair-sized haystack. No depth could be found with any appliance we had. The explosion had thrown up great quantities of limestone, much of it a distance of ten or twenty rods away. Another small crater was discovered in the same depression."*

We earlier suggested that groundwater might rise like a geyser. Perhaps we could have used a metaphor closer to that of an artillery shell.

> *"The season had been very dry, and great numbers of animals and snakes came around this phenomenal lake to drink. The water thus thrown up did not subside for months, but continued to flow until the water had filled all the lowest land for miles around..*

> *"We had occasion to go further west and were gone for four days, and on returning took the trail that we had gone out on, but found our lately-trodden path now waist deep with water. We had to go back and around on the higher ground to get back to the house.*
>
> *"My theory of this outburst of water is that from some particular stoppage of the great underground flow of water from a marsh some forty miles south of its outlet in Castalia Creek it had to have vent, and came out through the surface where the crust was thinnest."*

Given the explosive nature of the even, this well may be true, but more consistent with the geology would be water pushed up a re-opened sinkhole.

> *"In subsequent days an underground river course has been discovered in and near Bellevue, Ohio, which is now within one and one-half miles of then place I have attempted to describe. Written from memory, at the request of friends, this 28th day of May 1888, the writer being twelve days past his eightieth birthday."*
>
> *The water of this underground stream is remarkably sweet, though it is so thoroughly impregnated with limestone that a calcareous crust rapidly forms in a tea kettle in which the water is boiled. The bubbling springs and the underground river have been sources of mucsh curiosity for years. The story of the formation of a lake in a single night is not known to any extent among the younger farmers and their families. It is a fact, however, that the same thing is likely to happen again should the subterranean stream become dammed, and then people of that part of Ohio may wake up some morning to find their farms afloat.*

Note the concern that the subterranean stream someday may someday become dammed. We'll see like accusations a century later.

This excerpt "A Flood From Underground Waters at Bellevue, Ohio," Engineering News Record, May 1, 1913, illustrates the confusion regarding the direction of subterranean flow.

> *But the flowing of the sinks is not the most peculiar part of the present phenomenon. One would suppose that the water flowing from the sinks would be flood water admitted to the underground passages at a higher level and discharged at a lower one. This supposition seems to be disproved, because the water flowing from the sinks in many instances is wholly different from the flood water. In that it is crystal clear and Impregnated by mineral deposits resembling the water coming from the immense Blue Hole spring at Castalia, seven miles north of Bellevue, or the famous Green Spring at Greenspring, twelve miles to the west.*
>
> *Sinkholes in Bellevue, right in the midst of lakes of flood water are spouting aqua pura from unknown underground reservoirs. Unquestionably there exists an underground water channel under the section of the state referred to, but all attempts to locate its place of discharge have met with failure. Corks and cork dust and other material of buoyancy have been introduced in the sinks at Bellevue in an effort to locate the mouth of the underground river, but nary a sign of any of these telltales has been found either In the Blue Hole at Castalia or in Sandusky Bay.*

Nearly 20 centimeters of rainfall in 3 days of June 1937 caused numerous sinkholes to up-flow. As reported by the June 29 St. Petersburg Evening Independent, the "mysterious" aspect remained.

> *George Burgess, safety director of this northern Ohio City of 6,000, said mysterious underground rivers -- which with heavy rains caused the flood in the first place -- would not permit the surface water to drain away normally for several days.*

A report by Myron T. Jones, engineer and attorney, in the April 1, 1938, Bellevue Gazette was at least on the right track.

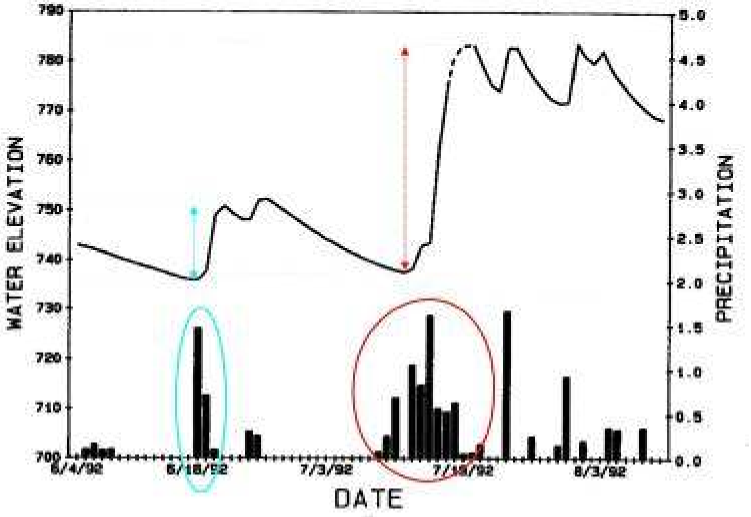
> *The City of Bellevue, a large part of Thompson Township in Seneca County, most of York Township of Sandusky County and the south-west part of Groton Township in Erie County have no other drainage than sinkholes. The whole district has an underlying strata of corniferous limestone... Some of the sinkholes are natural, others artificial, being constructed by drilling and testing until a crevice or fracture capable of taking a sufficient quantity of water to be useful*

> *is found. Some of the sinkholes are connected underground. Tests have been made to determine whether the Kinney sinks have any connection with the underground river emerging from the Blue Hole at Castalia which tended to prove they did not. Sinkholes in the lower areas have been known to spout water during flood times, which could only have been caused by pressure through connected fractures from higher land... If the water from the region south of Bellevue can be taken care of by surface drainage facilities much of the trouble existing in the low lying sinkholes area around Bellevue will be eliminated.*

But oh, as we shall see, were remediation that simple!

Bellevue was again inundated in 1969, this time by 25 centimeters of rain in just 16 hours. The city's main street was covered by up to 3 meters of water and 1,100 basements were flooded.

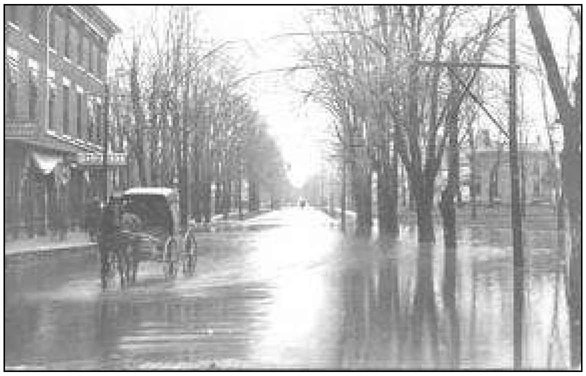
By 1992, the Ohio Department of Natural Resources (ODNR) was monitoring the watershed. A 6-centimeter 2-day storm in 1992 caused the water table to rise roughly 5 meters. After 21-days of recovery, 16 centimeters of additional precipitation over 9 days raised the level 15 meters. The graph demonstrates the rapid and dramatic response of groundwater levels to rainfal



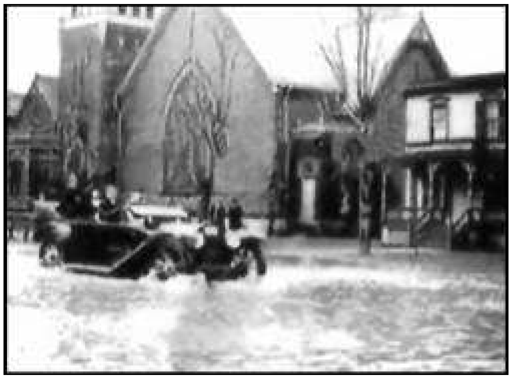
Cumulative precipitation from October 2007 through March 2008 was 23 centimeters above normal, and 14 centimeters in March was the third wettest for that month in 126 years. An April storm then brought 13 centimeters of rain over 6 days, elevating the water table by 15 meters, causing the United Church of Christ to rally relief for victims of "The Flood from Nowhere."

The owner of Seneca Caverns noted that the groundwater on April 1 was but 11 meters below land surface. Ole' Mist'ry River had become a rapidly filling column. After a month of intermittent rains, the level was still 9 meters higher than before the rainy season. It would take more than two additional dry months to return to the initial state.

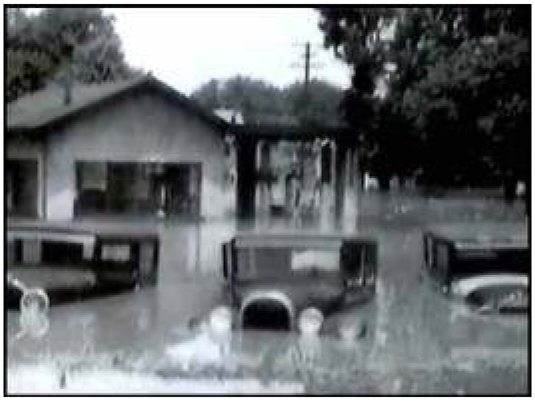
Bellevue, Ohio, U.S.A.



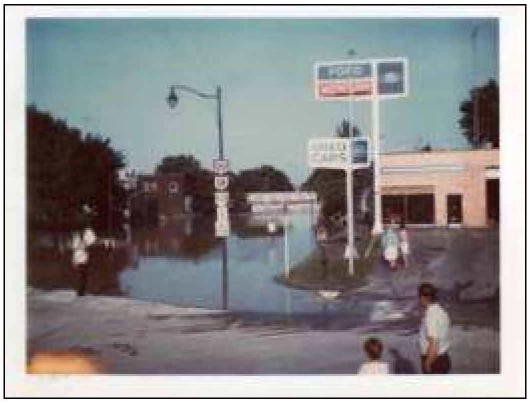
1883



1913



1937



1969

"The Flood form Nowhere," 2008

2008

What could be more disconcerting than inundations from geysers?

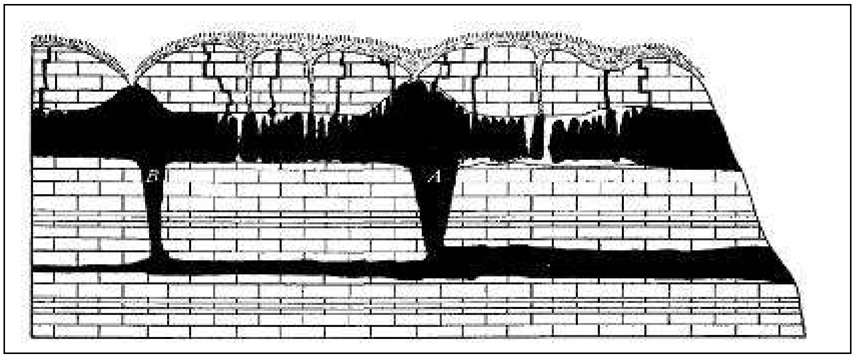
How about geysers of sewage?

Sewage Disposal

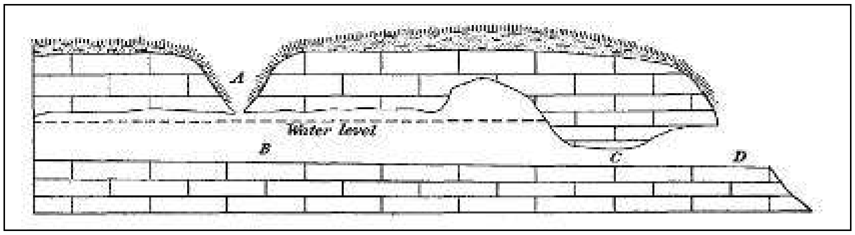
From "Pollution of Underground Waters in Limestone," Water Supply Paper 258, USGS (1910) by George Matson,

> *The practice of putting rubbish, barnyard filth, etc., into sinks should be abandoned. Still more reprehensible is the custom of running sewage into sinks, thus converting the underground channels into natural sewers. This practice, which is by no means uncommon, is often defended by the assertion that the water in limestone channels beneath a city is unfit for drinking even without the sewage.*
>
> *The correctness of this assertion can not be disputed, but there are persons who are ignorant of the danger and who continue to use the underground water. Moreover, those living at some distance from the city may use water from the underground channel which receives the sewage. For these reasons any city which proposes to convert an underground watercourse into a sewer should be forced to trace the channel to its destination so that others may be protected. There is need of legislation to prevent the unnecessary pollution of underground streams. Such legislation has been enacted for the protection of surface water, but the protection of underground water has been entirely neglected.*

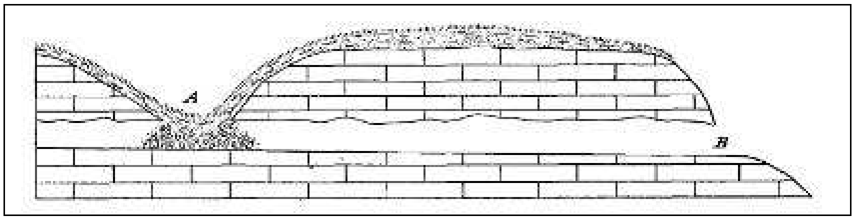
Matson's agreement that "the water in limestone channels beneath a city is unfit for drinking even without the sewage" is incorrect, but indicative of understandings a century ago. As the paper raised the issue of pollution of karst streams to the highest levels, we'll show a few it its illustrations.



Different levels of underground streams



How sediment may be deposited by the underground stream.



How sediment may be obtained by the underground stream

Again from The Ohio Guide, Federal Writers' Project (1940),

> *Bellevue has a unique sewerage system. Throughout the underlying rock strata flow many streams, honeycombing the area with sinkholes. Through these the town disposes of its sewage. In times of heavy rains, however, the streams back up and geysers spout of the earth; the low-lying parts of the city are flooded, and Bellevue becomes a beleaguered city until the water evaporates or seeps away.*

When settlement began in Bellevue, homeowners employed two wells, one for water and one for wastewater disposal, the latter drilled until the bit dropped into a subsurface void and often equipped with a hand-operated ramrod to keep it open. By the time a municipal reservoir was constructed in 1872, domestic, industrial and municipal wastes were routinely mainlined into what was known as the "Bellevue Underground River."

We use the verb "mainline" deliberately. Groundwater pollution most commonly stems from waste disposal on or into the upper soil horizon. To get to the water table, the constituents percolate through the granular media with opportunity for biodegradation, physicochemical reaction and natural filtration. What enters the groundwater may still be of objectionable quality, but is probably manyfold less toxic than the initial product.

Mainlining into a subsurface stream not only decreases the mitigation afforded by natural processes; it injects the pollutants into rapid downstream conveyance. The downstream neighbor receives wastes not only less-degraded, but more quickly. The reader who associates "mainlining" with heron use isn't far afield. Mainlining is about shooting strong chemicals into a vein flowing directly to the heart.

While a municipal strategy of sewage mainliningsuch is woefully short-sighted from today's environmental perspective, the Ohio State Board of Health took it in stride at the turn of the century.

> *Bellevue has a unique method of disposing of sewage. Some 50 to 60 feet down there seems to be an underground stream or vein of considerable size, which is said to come to the surface at Castalia, north of there. Down to this current, wells or sinks are drilled into which all sewage and a great deal of the storm water is emptied. There are a number of these holes drilled by the city for street drainage and many more drilled by private parties to dispose of sewage. --* Report, Ohio Dept. of Health (1899)

The agency wasn't entirely comfortable with the practice, however, as evidenced by Ohio's Health (1917).

> *The Board does not consider the discharge of sewage into the underlying rock formations to be a proper practice. The existing method of sewage disposal in general use throughout the city is objectionable, as pollution of the underlying groundwater thereby results, endangering all water supplies in the vicinity which are obtained from this source. The drilled well maintained at the water works pumping station of the city should be plugged and made inaccessible as a source of water supply.*
>
> *In view of the extent of the practice of discharging sewage through sink holes at Bellevue and the likelihood that the use of this method, unless checked, will continue to increase, the officials of the city should give careful consideration to its suitability and safety as a permanent method. This department would advise its abandonment and the use of properly constructed sanitary sewers for the following reasons:*
>
> *1st. The practice of discharging sewage through sink holes pollutes the groundwater supply within an undetermined radius from the city and in this connection it is pertinent to consider the possibility of future use of such supply as a source of public water supply for the city;*
>
> *2nd. The method in use is contrary to the accepted principles of sanitary science and cannot be considered as a permanently satisfactory method of sewage disposal; and.*
>
> *3rd. Taking into account the installation cost for the use of this method and the likelihood that sooner or later it must be abandoned, it is probable that from an economical standpoint alone properly constructed sanitary sewers will be found superior.*

And And Bellevue's practice was by now a national curiosity. Here's the remainder of the 1918 Encyclopedia Americana entry.

> *The most unique feature of the city is its sewerage system. An underground stream flows beneath the city into Lake Erie and on each block is a hole drilled to this stream which thus serves to dispose of all sewage and surface water as well.*

An enthusiastic engineer, LeFever M. Lee, touted subsurface mainlining's economic advantage in "Caves Form Bellevue's Sewage System," Ohio State Engineer, November 1929.

> *What is probably the most unique and cheapest sewage disposal system in the country is found at Bellevue, Ohio, located about one hundred miles north of Columbus on the county line between Huron and Sandusky counties. This area is underlaid by limestone which dissolves by the action of water, forming caves, fissures, and sink-holes. In this locality the fissures are found close to the surface and have water flowing through them the year around.*
>
> *The city of Bellevue takes advantage of these conditions to dispose of its sewage by drilling holes through the limestone in much the same manner as people living on a farm drill a well. If an opening in the rock is not found within a depth of about two hundred feet, the drilling machine is moved to another place within ten or twenty feet of the first attempt and another hole is bored. It is a rare occasion when a third try must be made, because the fissures are very numerous and close to the surface. The majority of the homes of the town have their own sewers, but it is not unusual for two houses to share the same one, thus lessening the cost for each family. Nearly all of the streets drain into pipes that lead to natural sink-holes located in various sections of the city.*
>
> *This sink-hole area varies from three to eight miles wide and extends to the west of Carey, which is approximately forty miles to the southwest. West of Carey is a cave that leads to an underground stream which is as close to the origin as anyone has been able to trace. From here the stream flows through the cracks in the limestone to Bellevue and then probably finds an outlet somewhere in Sandusky Bay. There are many places along this subterranean river where it comes to the surface in the form of springs and wells. On one or two occasions the river has become too full and turned a number of the sinkholes into springs, but these always*

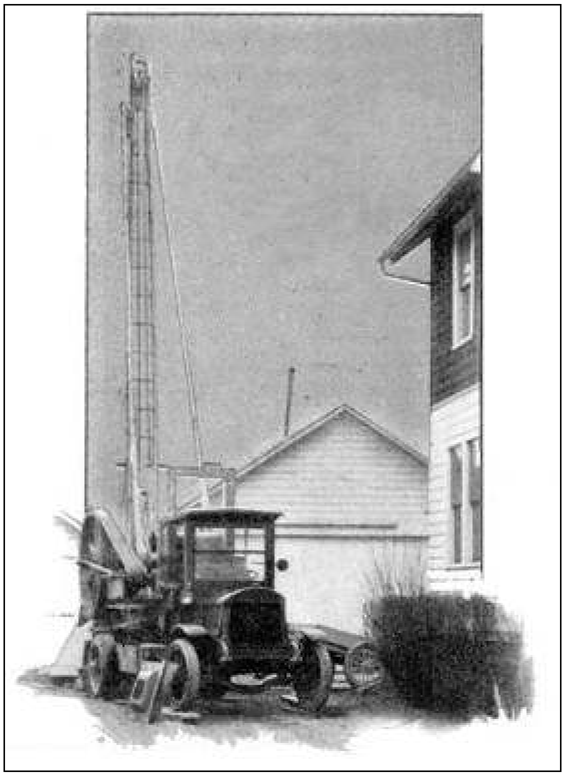
> *subsided when the river receded. After the flood of 1913 water stood on many of the farms north of Bellevue in ponds of as much as 10 or 12 acres, because the fissures were filled with water from the neighboring country. It is a matter of conjecture as to where the final outlet for this river is located.*
>
> *Experiments by the state health authorities with chemicals to determine this outlet settled nothing farther than a northward trend of the current which was already known. Other experiments, by Professor E.L. Mosely of Bowling Green and E.F. Warner of Bellevue, with ground cork and small corks proved nothing. In the floor of Sandusky Bay there are springs, but it has never been proved that they are a part of the rest of the system. None of the wells or springs in this neighborhood show any impurities from the use to which the river is put when it passes under Bellevue. Thus it is that this little city has one of the cheapest and most sanitary sewage disposal systems known.*

We can indeed agree that it was the cheapest, but 40 years later when Lake Erie was near death, the final outlet was no longer a conjecture.

The assertion that "None of the wells or springs in this neighborhood show any impurities from the use to which the river is put when it passes under Bellevue," suggests that the author was not aware of the Ohio Department of Health's reservations 12 years before.

"Mysterious Lost Rivers Run Mills and Power Plants," Popular Science, November 1934, again brought Bellevue's practice to national, if yet again uncritical, attention.

> *Where does the waste material go? No one knows. It is believed that an underground stream caries the sewage away. A single well can handle two houses. Fortunately, the waste material dumped down the garbage wells of Bellevue does not remain to contaminate the surrounding soil. Excellent fresh-water wells have been drilled with success within the city limits.*



Drilling a well into an underground river for garbage disposal.

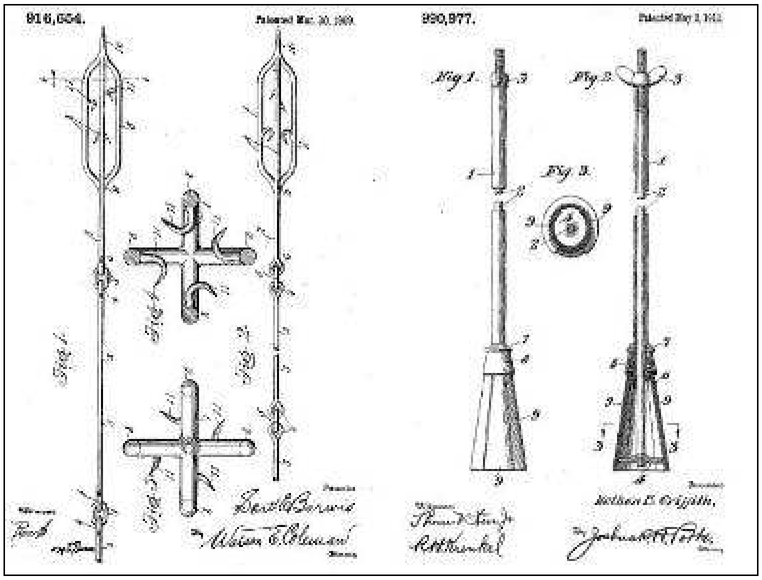
One of the drilling outfits used in this work. In some towns the wells do the work of sewerage systems.

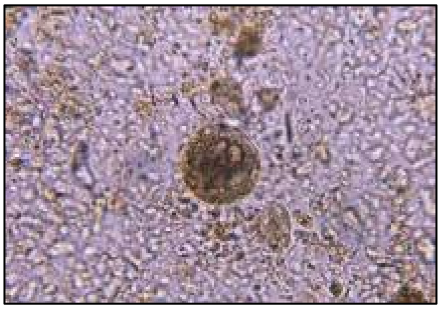
Perhaps, as you read this, you are sitting above a subterranean river that would rank with many a fair-sized surface stream. Where do these unseen streams flow? What causes them? What influences do they have on surface conditions? Are they of any value? These are a few of the questions that have gained the attention of geologists. Answers have been provided in some cases. But, on the whole, the underground creeks, rivers and lakes of the United States and the rest of the world remain very much a mystery.

The "very much of a mystery" is but a ploy to garner reader interest. The tendency of wastewater wells to geyser in times of heavy rain and the septic nature of the outflow were well understood.

We note the story's two-time use of "garbage," hoping that the writer thought the term synonymously with "sewage." On the other hand, a standpipe to an unseen cavern might indeed have seemed a convenientmed place to dump any manner of refuse.

Some 1500 brick-sheathed or perforated pipes conveyed wastewater from 5 to 30 meters into the karst under-layer. As for maintenance, American ingenuity is indefatigable.





The expression "The shit hit the fan" describes the impact of the 1937 flooding discussed earlier. More accurately for Bellevue, however, would be "The feces floated into the parlor," the indicator often being B. coli.

The situation can be adequately illustrated by taking the karst cross-section in the previous section and changing the three shades of blue to corresponding shades of brown.

From "Sunken Stream Gives Up and Floods a Town," Chicago Daily Tribune; June 28 of that year,

> *Natural Sewer Reverses in Bellevue, Ohio.*
>
> *Bellevue is built from 20 to 50 feet above the level of an underground stream that, for want of a better name, had been known colloquially as the "Bellevue underground river." It empties into Sandusky bay, an arm of Lake Erie.*

> *Even in the days before indoor plumbing, and by some folks since, it was considered godsend. You could did almost anywhere in town to bedrock, where its natural slope would carry the drainage into the sunken stream. When some areas of the town were joined by a common sewage system it too was run into the underground river. It saved a good deal of money.*
>
> *Last Friday, early in the morning, it started to rain. It poured for eight hours. The sunken stream, already swollen by several days fall of water over the area it drains, couldn't take it. The pressure forced the water back up the sewers, back up the sinkholes, and through the crypts the citizens not on the sewer system had dug.*

Although 90 percent of the city's basements flooded with raw sewage, remediation was opposed because of the costs of a treatment plant, sewer lines and redoing the plumbing in thousands of homes.

Additional municipal water wells were drilled in the early 1940s at depths ranging from 42 to 61 meters. But by 1944, several of the wells were contaminated and plans for an industrial well for soybean processing were abandoned due to contamination at 70 meters. All commercial and municipal water wells were relocated by 1946.

By 1960, there were more than 1400 privately-owned sewage disposal wells or sinkholes within the city and more than 200 municipally operated disposal wells discharging toilet flushes, restaurant and laundry wash water, kitchen garbage, bath water, mortuary and hospital refuse into the underground cesspool.

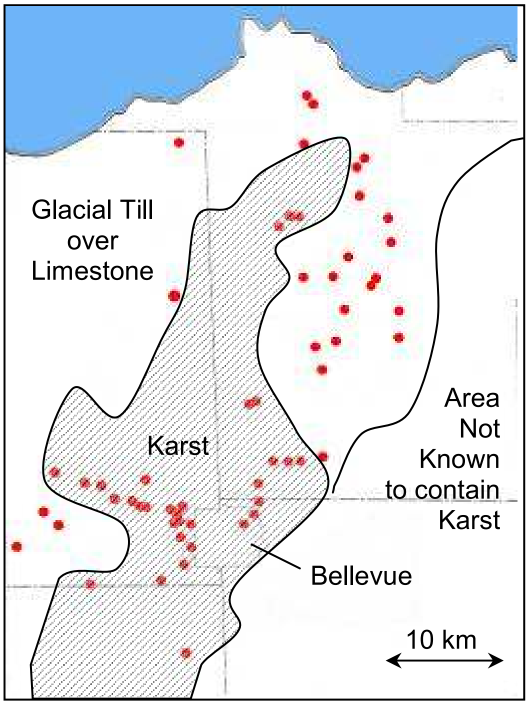
We don't want to know more about the mortuary waste.

It wasn't until 1961, however, that the state recognized the broader consequence of mainlining the sewage -- a 200 square-kilometer northward swath of pollution.

From Contamination of Underground Water in the Bellevue Area, ODNR (1961),

> *Contamination of a highly-permeable limestone aquifer had resulted from the dumping of household, municipal and industrial wastes into scores of sink holes and drilled wells. In many instances septic tanks were used, but overflow from the tanks was allowed to discharge into wells. The sewage effluent contaminated the groundwater as it moved down the water-table gradient toward Lake Erie.*

Red circles show reported sites of contamination



> *Wells occasionally would become plugged with sewage, necessitating redrilling. With the increased use of detergents, plugging ceased to be much of a problem. Division of Water investigators found more than 1500 disposal wells within Bellevue's city limits-an area less than 4 square miles.*

> *Of 32 samples of groundwater collected in the vicinity of Bellevue, 27 contained ammonia. Detergents (alkyl benzene sulfonate or ABS) were found in 22 samples, and all contained nitrate and phosphate.*

Concentration (mg/l)	$N0_3$	$N0_2$
Bellevue wells, February-April 1961	29	0.50
	52	0.05
	92	0.00
	158	0.00
	41	1.00
	38	0.05
	26	1.50
	36	0.00
	77	0.05
	91	0.20
EPA Drinking Water Standard	10	1.00

> *The ground-water resources in the Bellevue area, and in areas down-gradient from the town, are obviously grossly contaminated and have been for more than a half century. The Division of Water report states.*
>
> *Stories have been related to us during this investigation, of wells which yielded easily recognizable raw sewage (including toilet tissue) while being drilled. Others have foamed because of high detergent content, and still others, the contents of which are best left to the reader's imagination.*

As toilet paper and surfactants seem sufficiently undesirable, we need not specify what else might be imagined. We should note, however, Bellevue's secondary drilling service sector, drillers who replace disposal wells unmanageably clogged with the items we're not imagining.

Municipal officials, however, weren't promoting action.

Official	Position	Source
City of Bellevue	*The only place to discharge* [treated] *effluent would* [still] *be into the underground caverns and this is what the state water commission objects to now.*	Toledo Blade, April 19, 1962
Commissioner of the Bellevue Health Department	*Officials of Bellevue, since the original inception of the use of sink holes, had made studies in the area and could find no evidence of water contamination.*	Freemont News, June 24
Public Service Director	*The geologists' report ... failed to prove that contamination originated in the city.*	Springfield Daily News, June 28

Nine out of ten citizens objected to the treatment proposal and plans to construct a wastewater plant were shelved.

But the times, they were a-changin' and the oppositionopposition faded in the late 1960s when federal funds became available for wastewater treatment. . The July 10, 1969, Toledo Blade, recorded the turn-around,

> *Bellevue Maps Cleanup to End Disease Threat. Plans to disinfect areas of stagnant water containing raw sewage in the flood-ridden city of 9,000 are being completed.*

And a flood the week following drove home the urgency.

> *Four sections of Bellevue were still under water late last week. The Bellevue storm drainage system is mainly a natural network of underground solution channels in limestone. The torrential rains raised the water table so high that water mixed with sewage rose out of the ground from sink holes, and the residents are still trying to pump water off to ditches that drain*

> *into Lake Erie. The flooding caused an estimated $250,000 damage to Bellevue's $4.5-million sewage interceptor and treatment plant started last spring.* -- "Ohio Storms Burst Two Reservoirs," Engineering News-Record, July 17, 1969

The treatment plant was completed in 1971 and America's mainlining of sewage into underground rivers ended in the United States.

While one would hope that Bellevue's sewage woeswash-up were thus ended, complaints were yet in litigation as late as 2006 regarding contamination by a stormn event that raised well levels 9 meters in a 3-hour span. The class-action suit was against the hospital -- recently rurally relocated -- for its storm water injection, but the counter claim was that up-flowdomestic waste from the plaintiffs' septic systems was flowing onto hospital property.

Concrete Plugs?

If there's aone common theme in the many aspects of underground rivers, it's that preconceptions don't die easily. Halting -- or at least substantially reducing -- Bellevue's blatant pollutionwater quality degradation didn't decrease the karst flooding and a chronic problem breeds renewed speculation regarding cause.

"Fountains of the Deep Break Open," the Plain Dealer, May 8, 2008, catches the public frustration regarding frequent inundation, albeit onow of somewhat less septic quality.

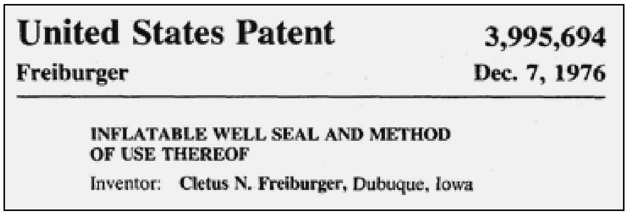
> *Precipitation measured at nearby Fremont was 69 percent above normal for the period of February 1 through March 18.*
>
> *Finally, the subterranean labyrinth could hold no more. As the pressure built, it drove groundwater up -- up through fissures in the underlying limestone, up through storm sewers and up through the concrete walls and floors of basements.*
>
> *Spontaneously formed ponds still cover basements, farms and roads. No one has put a dollar figure on the damage yet. But in all, 200 or more homes have been afflicted, local officials say.*
>
> *This kind of flooding isn't unprecedented here -- but it is rare. The floods came in 1969 and 1937 and 1913, said Jeff Crosby, Bellevue's safety and service director.*
>
> *A mile down Ohio 269, residents blame each other. One says neighbors up Strecker Road prevailed on the county to knock down levees two years ago so a drainage ditch wouldn't overflow onto their new homes. Others suspect neighbors -- even friends -- have filled sinkholes with concrete, a practice that hydrologists and geologists condemn.*

From WKYC-TV's "New Theories about Bizarre Flooding in Bellevue, Ohio," aired April 25, 2008,

> *Residents in this small town in Huron County have been coping with floods for five straight weeks. Some of them theorize that something has plugged up one or several of the underground sink holes, pushing millions of gallons of water to the surface.*
>
> *Viewed from the air, it's hard to imagine that the dozens of small lakes and ponds all suddenly appeared five weeks ago. The earth has pushed up millions of gallons of spring water to the surface of this rural community against logic and against gravity.*
>
> *There are no visible rivers or streams for miles around that would explain the destruction.*
>
> *79-year-old Dick Bell has been studying the cave system in the county for more than fifty years. He says there may be hundreds of similar caves and sink holes in the area surrounding Bellevue. He says that normally all the water flows like an underground river toward Sandusky Bay.*
>
> *"It's all loaded with water down there and it's all flowing downhill to the north," Bell said. "Every 30 years or so, something happens to block that flow and, boom, the flood appears."*
>
> *"I can't say for sure what's doing this, but I sure hope somebody hasn't filled up sink holes on their property and shifted the way the water flows out," he said.*

> [Resident, Bob] *Hammersmith believes that his neighbor plugged up several sink holes with concrete and changed the way the artesian spring water drains from the surrounding properties.*

While most hydrologists and geologists may doubt that dumping concrete down a few holes would do the job, there's a solution at the U.S. Patent Office.

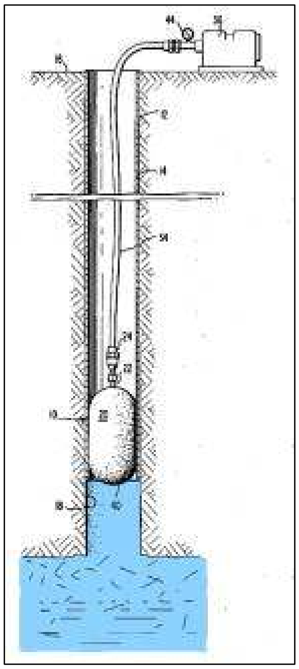


United States Patent **3,995,694**

Freiburger **Dec. 7, 1976**

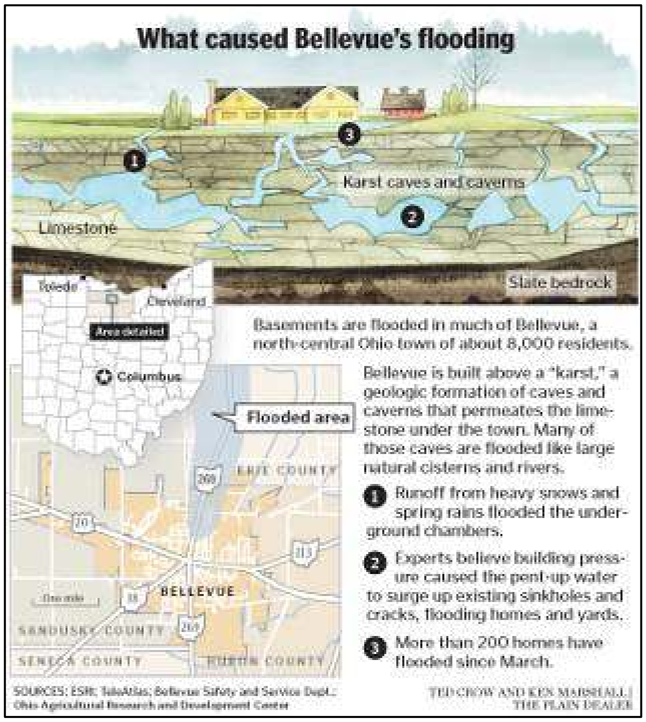
INFLATABLE WELL SEAL AND METHOD OF USE THEREOF

Inventor: **Cletus N. Freiburger, Dubuque, Iowa**



> *The abandoned wells can pollute these operational wells because the wells are usually connected by underground rivers or streams... Due to the great depth of these wells, and the fact that the bottom of the well shaft opens directly into the water source, it would be quite impractical and nearly impossible to merely pour concrete or other hardenable substances into the well shaft to seal the well without first implanting a base structure in the shaft of the well*

Let's look again at WKYC's title, "New Theories about Bizarre Flooding in Bellevue, Ohio." There are no new theories. The television reporter simply appears to have missed the previous day's Plain Dealer, its graphic shown to the right. 1, 2, 3 can hardly be called bizarre.



What caused Bellevue's flooding

Basements are flooded in much of Bellevue, a north-central Ohio town of about 8,000 residents.

Bellevue is built above a "karst," a geologic formation of caves and caverns that permeates the limestone under the town. Many of those caves are flooded like large natural cisterns and rivers.

① Runoff from heavy snows and spring rains flooded the underground chambers.

② Experts believe building pressure caused the pent-up water to surge up existing sinkholes and cracks, flooding homes and yards.

③ More than 200 homes have flooded since March.

SOURCES: ESRI; TeleAtlas; Bellevue Safety and Service Dept.; Ohio Agricultural Research and Development Center

TED CROW AND KEN MARSHALL | THE PLAIN DEALER

ODNR likewise attempted to resolve the blockage question in Ground Water Induced Flooding in the Bellevue Ohio Area (2009),

> *Q: Has the flow in the aquifer been blocked?*
>
> *ODNR: No. However, the number of sinkholes and the pathways for groundwater movement change over time.*

But who's going to believe the government?.

Bellevue Alone?

Although the 1934 Popular Science reported, "In some towns the wells do the work of sewerage systems," the plurality was not elaborated. The 1961 ODNR study described the Bellevue situation as "an unusual, but by no means unique," but again without expanding.

So we'll note similar cases.

"Florida," Medical Record, October 17, 1891, touts Ocala, Florida for recuperation.

> *Ocala has been called "one of the best planned and most picturesque cities of the South," possessing paved streets, street railways, an electric light plant, a wholesome and desirable water-supply, and a remarkable system of natural sewerage formed by a swiftly flowing underground river eighty to one hundred feet beneath the surface.*
>
> *The indications for a sojourn at Ocala are pulmonary and throat troubles, chronic rheumatism, gout, senile debility, and an enfeebled nervous system.*
>
> *It seems to be an underground river that has come to the surface for a glimpse of daylight.*

Ocala still disposes of nitrate-laden storm water runoff into 28 sinkhole inlets. The Rinker Truck Cleanout Pit empting into a sinkhole is shown to the right.

Not until 1960 did the city of Live Oak, Florida abandon its wastewater disposal wells. Why it wasn't decades earlier, however, speaks poorly of state enforcement, given the Florida Statutes Act of June 7, 1915.

> *367.02 No municipal corporation, private corporation, person or persons within the state shall use any cavity, sink, driven or drilled well now in existence, or sink any new well within the corporate limits, or within five miles of the corporate limits, of any incorporated city or town, or within any unincorporated city, town or village, or within five miles thereof, for the purpose of draining any surface water or discharging any sewage into the underground waters of the state, without first obtaining a written permit from the state board of health.*

From Popular Science, October 1885

> *The authorities of Albany, Georgia, have efficiently drained a troublesome pond by boring a well hole through the ground to a deep subterranean stream. An outlet for the sewerage of a large Western university has been found in one of the numerous "sink-holes" with which the cavernous limestone of the country is marked, where a similar underground stream carries the stuff to parts unknown. Such expedients are good, provided the subterranean stream selected for the sewer-outlet is not a source of supply for some well.*

St. Louis, Missouri is another example of the murky (literally) history of subterranean sewage disposal. From "Natural Sewage, Subterranean Passages Honeycomb the Ground Beneath St. Louis" in the San Francisco Call, February 28, 1892,

> *"Do you know," said Sewer Commissioner Southard, "that before the present sewerage system of the city was put in there existed a system of natural underground sewers which carried off the drainage of the city? Go down to the southern outskirts of the city and you will see scattered here and there square shafts of rough stone sticking up out of the ground, from one to ten feet above the surface. Look into one of these and it seems bottomless. Some of them, however, are different; you can se the bottom, and they appear to be just ordinary shallow holes. They have outlets, however, underground passages that wind far away into the earth, and through these the drainage escapes emptying eventually, I presume, into the river. Some of these holes, however, are over half a mile from the river.*
>
> *"Before the shafts were built they were simply sinkholes, generally in the middle of a wide and deep depression. They were walled in, however, the shafts built up, and the dirt washed down was held by them and the land leveled.*
>
> *"I think that they were caused by some great upheaval of the Mississippi Valley, possibly the same that caused the New Madrid earthquake in 1805. The land about them looks as if had been lifted up and let down, causing a sinkhole inn the middle. This same eruption doubtless produced the underground passage between the layers of limestone. Some of these shafts were built to the height of twenty feet; but the dirt has filled in about them until sometimes they are level with the surface of the ground. Twenty five years ago there were hundreds of them,*

> *and there are now between 100 and 200 that have been walled up. I have never seen anything like such an extensive system of natural underground sewage as this."*

As the St. Louis Sewer Commission of the time dealt with both wastewater and storm water, we can't be sure of the nature of this particular sewage, but in a hydraulic sense, it's the Bellevue story.

Robert E. Criss documents another Bellevue correspondence in "Human Modification of Karst in the St. Louis Area, Missouri" in National Cave and Karst Management Symposium, 2007.

> *Several homes along Conger Dr. were constructed along the side of a large sink, that according to one lifelong resident formerly hosted a cave entrance. The area was partly filled and graded, and is now traversed by an MSD* [Metropolitan St. Lewis Sewer District] *storm sewer. Several homes in the immediate vicinity still have septic systems, while others are connected to municipal sewer lines.*
>
> *The residence of Alice Bradenberg at 11606 Tescord Drive has experienced repeated flooding since 1966 due to backflow from a sinkhole into which too much storm water has been diverted). Ms. Bradenberg reports that the water from the "drain" can "geyser" several feet into the air following storms.*

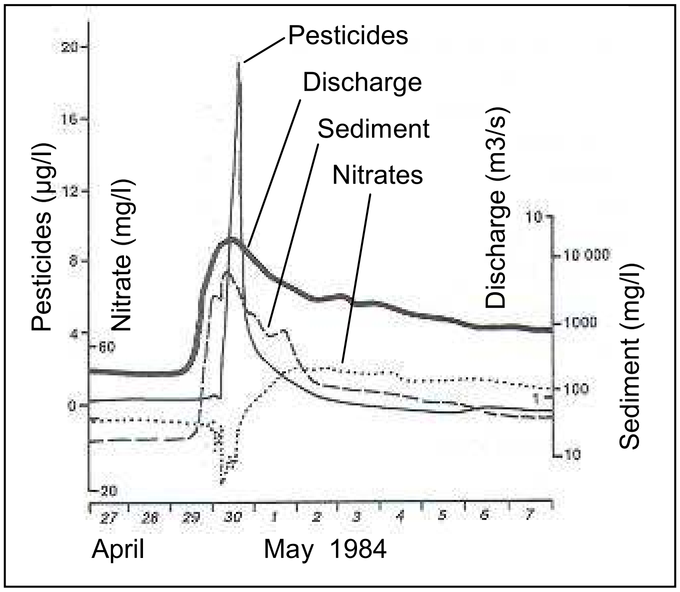
A photo illustrates a sinkhole collapse.

> *Collapse near a storm drain situated in a sinkhole in the Concord area. The capacity of the natural bedrock conduits is too small to drain storm water as fast as it is delivered, so this yard frequently floods to depths of several feet.*

"Agricultural Impacts on Ground Water Quality: The Big Springs Basins Study, Iowa," Proceedings, Agricultural Impacts on Ground Water Quality, National Water Well Association (1986) by R.D. Libra, G.R. Hallberg, B.E. Hoyer and L.G. Johnson describes the effects of sinkhole-capture on environmental quality in a 267 square-kilometer groundwater basin.

Impacts of a 7.4 centimeter storm during the late hours of April 29 are shown to the right.

A karst system's response to a rainfall event can indeed be rapid.



"Ground Water Flow in Limestone Terrains," Proceedings, Fifth National Symposium and Exposition on Aquifer Restoration (1985) by J.F. Quinlan and R.O. Ewers describes how sewage, creamery waste and heavy metal effluent was spread to 56 springs along an 8-kilometer reach of the Green River in Kentucky's Sinkhole Plain.

Research at Huazhong University of Science and Technology suggests that advantages of underground river-style dry fermented garbage processing include,

> Large quantities of refuse can be treated,
> Refuse can be immediately treated on site, and
> Little land is required.

For those who read Chinese, see Yuan Yuan, et. al., "Medium-Scale Experiment Study on Biomass Anaerobic Digestion by Underground River," Renewable Energy, June 2006, and Cheng-Bao Leng, et. al., "Study of House Refuse by Dry Anaerobic Digestion in Underground River," Environmental Engineering 19:4, 2001.

And let us not forget the End of the World. From "Sonia, A Story from the End of the World" by Michael Crane, Meanjin, June 2007,

> *I am the storyteller at the End of the World. Everyone asks me what the place looks like. The End of the World is a huge sprawling metropolis built on rock-hard clay, and beneath it runs a 100-mile-wide underground river that ends at the End of the World and becomes a giant waterfall. The river acts as the sewerage of the physical life, and also for the souls of people at the End of the World. In every kitchen there is a hole in the floor where the people deposit their garbage and this is carried by the river and over the edge of the waterfall.*

Wherever and whenever, we endorse the advice given in "Water and its Dangers," Maine Farmer, June 13, 1895.

> *Wells within a hundred feet of the house may be pure, but there is great possibility of underground streams reaching it from far-away barns, if not from those at hand.*

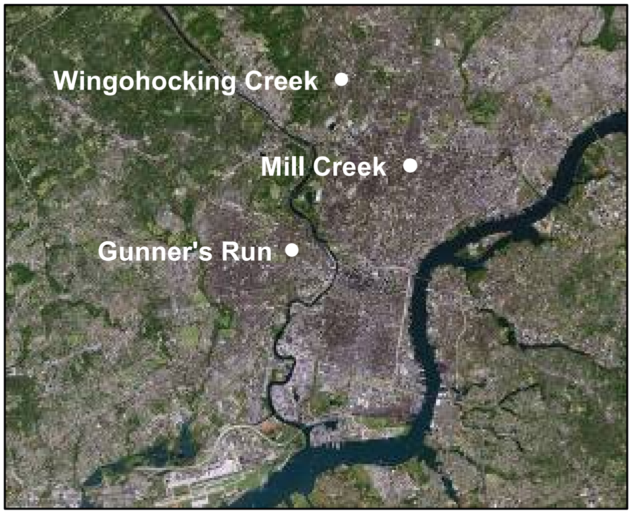
CHAPTER 76
REPERCUSSIVE URBAN SUBVERSIONS

The brook was thrown
Deep in a sewer dungeon under stone
In fetid darkness still to live and run --
And all for nothing it had ever done
Except forget to go in fear perhaps.
No one would know except for ancient maps
That such a brook ran water. But I wonder
If from its being kept forever under,
The thoughts may not have risen that so keep
This new-built city from both work and sleep.
from "A Brook in the City" by Robert Frost, 1923

A river relegated underground bodes unanticipated reprocussions for a metropolis above. This chapter deals with unintended consequences of naturally-flowing waters subverted into municipal sewers.

We'll begin with three examples from the City of Brotherly Love.
In the late 1800s, Philadelphia undertook a progressive plan to encapsulate its surface streams, eventually sewering 73 percent of its waterways, roughly the same percentage as that achieved by Washington DC.

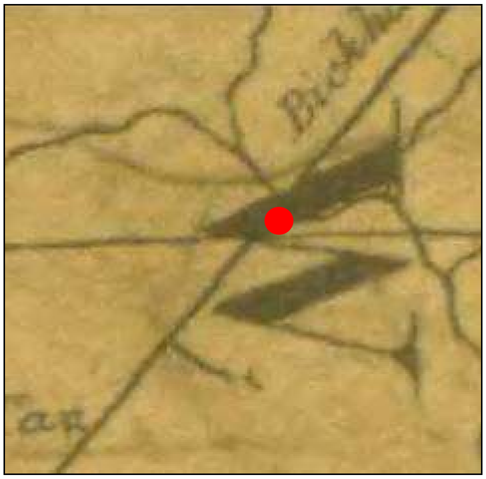
Such sewers were meant to convey natural discharge, augmented flow from paved surfaces, and effluent from indoor plumbing, an increased concern when it became known that typhoid fever and cholera were transmitted by foul water. Between 1860 and 1909, more than 27,000 Philadelphians died of typhoid.



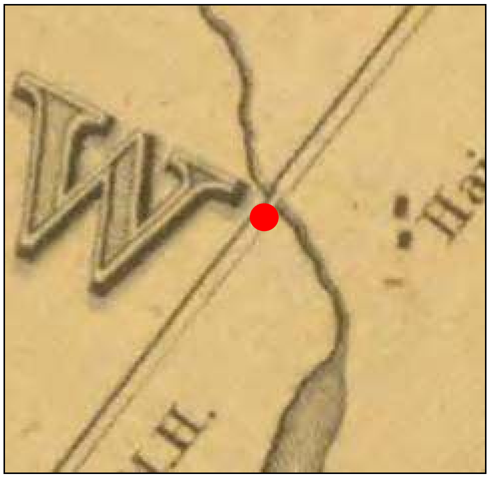
Wingohocking Creek, Philadelphia

Wingohocking Creek once drained some 25 square kilometers in the Germantown area with about 35 kilometers of channels.

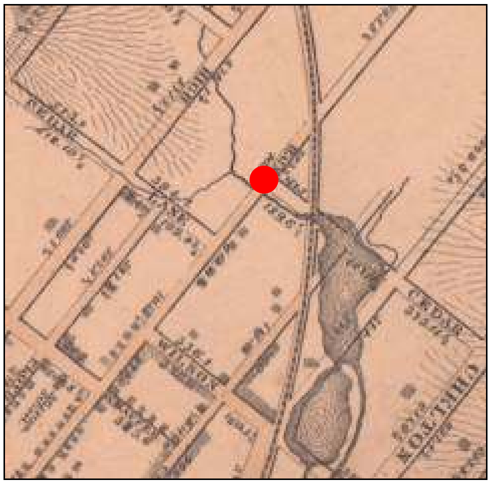
The maps that follow chronicle a portion of the urbanization and creek disappearance as sewer pipes, some exceeding 6-meters in diameter, subsumed the drainage. The red dot is the intersection of today's Musgrave and Haines Streets, a location to which we'll return.



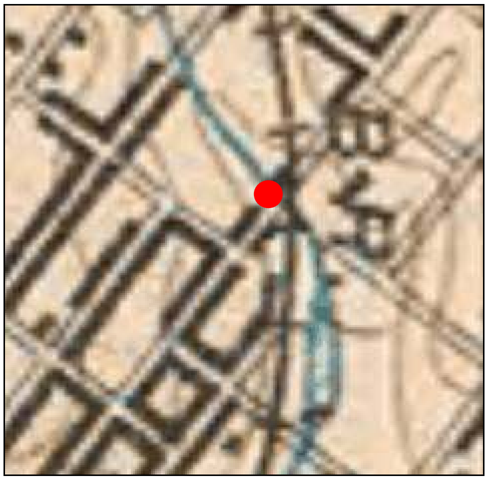
1808



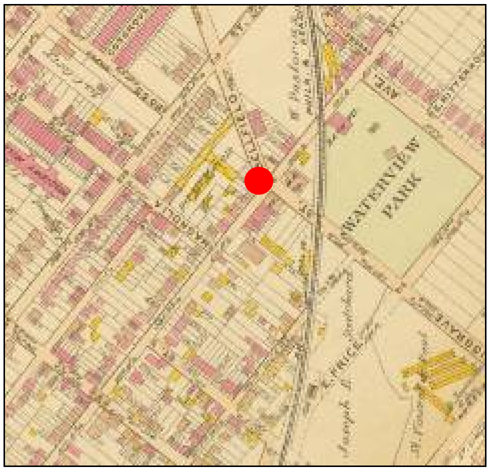
1843


CEDAR STREET

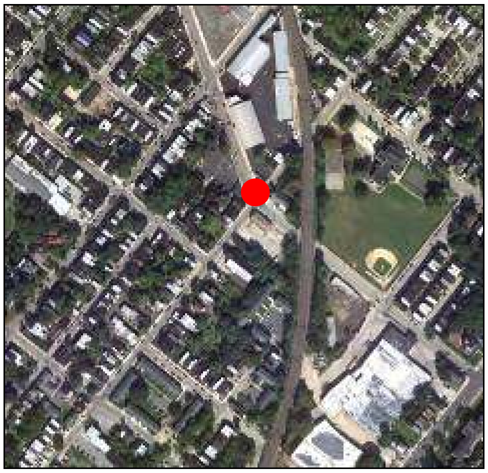
1862



1890-1910

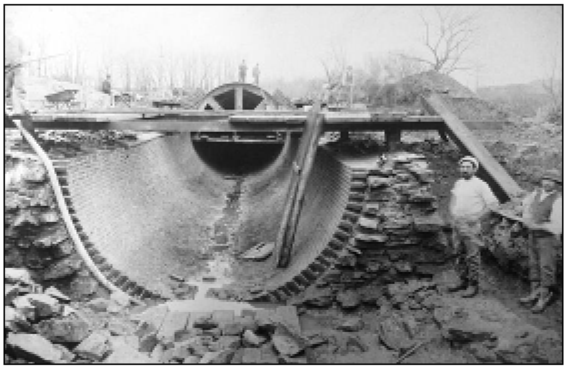

WATERVIEW PARK

1910

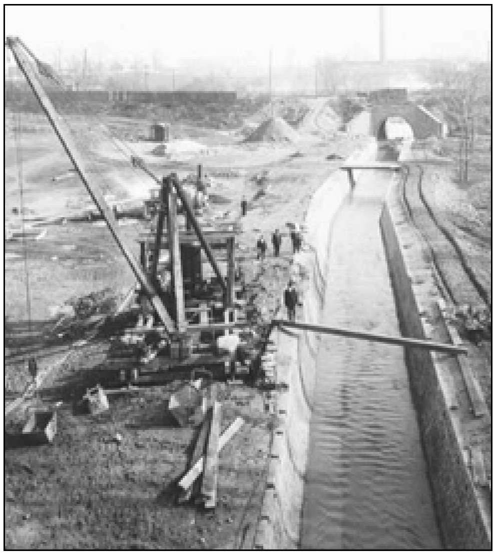


Today

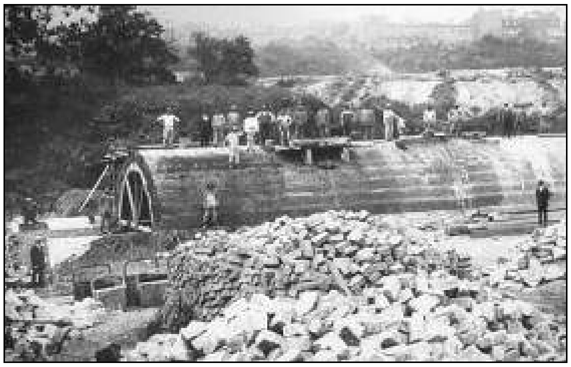
Wingohocking Sewer under construction



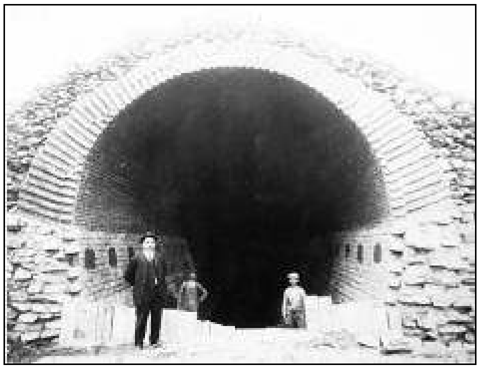
1890s



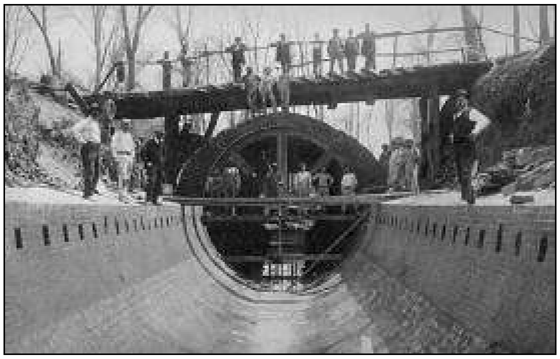
1909



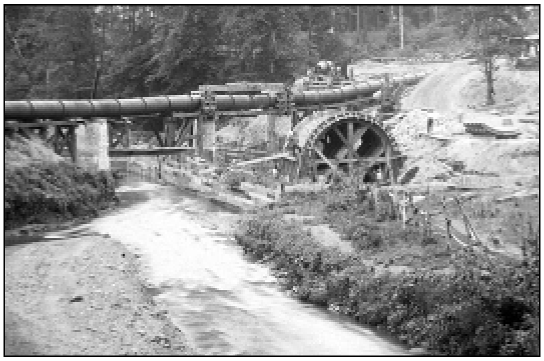
1914



1914



1914



1916. The pipe temporarily carried cross-flow.

From "Wingohocking Creek is to be Put Under Ground," Philadelphia Record, October 5, 1924,

> *The construction of the Wingohocking sewer will have the ultimate result of eliminating Wingohocking Creek which at the present time is an open sewer... It is estimated that aside from eliminating the health menace as represented by the open creek, the completion of the sewer will open up for development approximately 400 acres of ground.*

"Put Under Ground," perhaps, but not knocked out of the ring, Philadelphia being a city that merits a boxing metaphor.

The overbanks along the Wingohocking were filled with as much as 12 meters of ash and rubble, and the row houses built on such foundation began settling almost as soon as they were completed. More than 1,000 dwellings of this "Logan Triangle" had to be razed in the 1980s.

Logan Triangle, 1999

On September 8, 2011 a young woman drowned in a flash flood while driving at East Haines and Musgrave, an area on high ground and miles from open water.

From "Driver Drowns in Flash Flood in East Germantown," Philadelphia Inquirer, September 10, 2011,

> *A 27-year-old woman whose father is a Philadelphia police officer apparently drowned in her car after it was caught in a flash flood in East Germantown, police said Friday.*
>
> *The woman, whose name has not been released, called her father early Thursday and said she was trapped by flooding at Musgrave and Haines Streets, police said.*
>
> *The woman told her father that she had called 911, police said. She never arrived home, and when her father did not hear from her, he filed a missing-person report.*
>
> *Shortly before noon Thursday, police found the woman's SUV and, believing it to be abandoned, had it towed to a lot in West Philadelphia.*
>
> *Later, officers discovered the woman's body in the backseat. Hers is believed to be the city's first flood-related death this year.*

WHYY NewsWorks, September 8, 2011,

> *A 27-year-old woman died Thursday after calling her father -- a city police officer -- and 911 to report she was trapped inside her car because of flash-flood waters near the Waterview Recreation Center in East Germantown.*
>
> *The woman, whose name is not being released by police, made those calls from E. Haines and Musgrave streets around 2:30 a.m. When her father didn't hear back from her, he reported her missing at 10:35 p.m. Her Chrysler Pacifica had already been taken to a South 52nd Street lot by Top of the Line Towing, at the father's request.*
>
> *An hour later, police detectives investigating the missing persons report discovered her body in the back seat of the vehicle.*

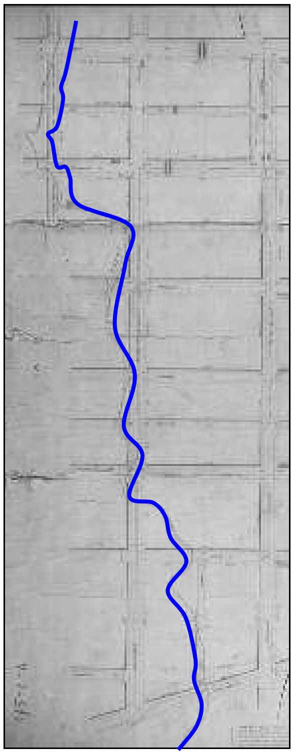
It did not escape the reporters that the fatality occurred above the long-buried Wingohocking. From "History Offers explanations for deadly Germantown Flood," NewsWorks, October 3, 2011,

> *Since combined sewers are necessarily connected to people's homes, when they are overwhelmed the water backs up into basements. Outside on the streets, water begins to pour out of sewer grates and manhole covers, at the same time that surface water has no place to drain. In an event like the one on September 8, when this section of Philadelphia received four inches of water in two hours, subterranean water pushes aboveground with enough force to create major flooding in basements and streets.*
>
> *According to the interactive mapping website Philageohistory.org, the location of the fatal flooding on September 8 is exactly above the buried Wingohocking.*

Buried streams exhume themselves when and where the public is least prepared.

Mill Creek, West Philadelphia

Draining 20 square kilometers of West Philadelphia, Mill Creek once powered grain, textile and other mills along the banks of the Schuylkill. Fast-flowing and fast-flooding, Mill Creek could discharge 150 cubic meters/second, destroying crops and creating seas of mud.

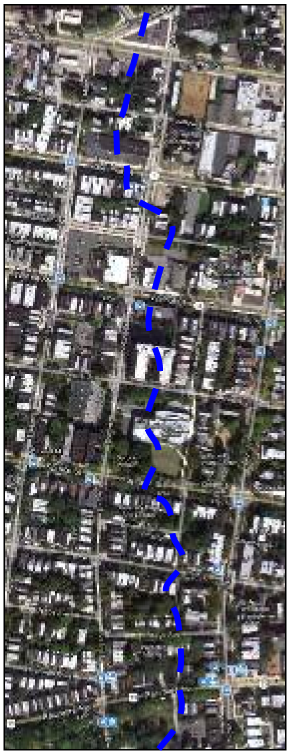


Near right, Mill Creek, 1852.

The Hopkins Atlas of 1872 shows the creek, hospital, home for orphans and mills within an overlay of platted properties.

The Bromley Atlas of 1895 no longer shows the creek. Row houses have replaced the mill buildings.

In the 1927 Bromley Atlas, a sinuous sewer line beneath blocks of row houses is the only vestige of the waterway.



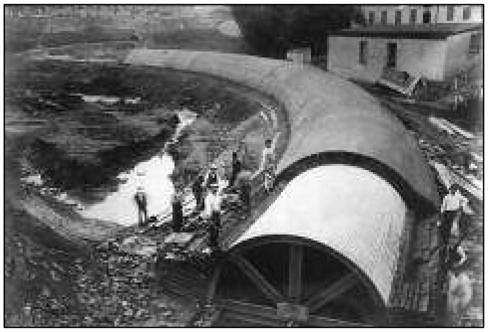
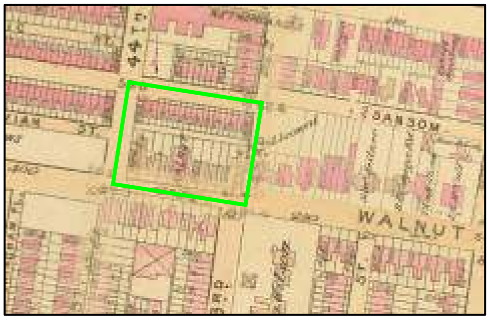
Far right, stream route

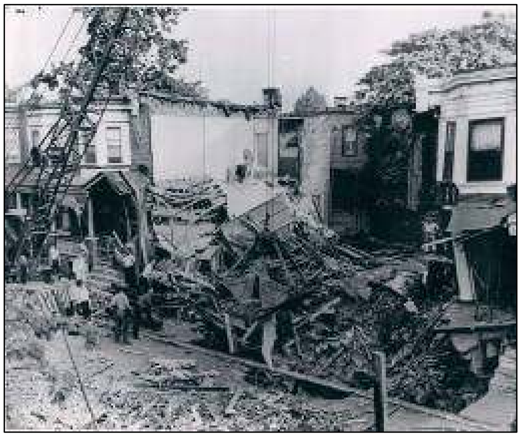
superimposed on modern photo.

Benjamin Boggs, an area resident, wrote about the creek in 1912:

> *Standing upon City Line bridge over the railroad one may see... the headwaters of Mill Creek, a tiny stream sparkling in the sun shine beneath the line of old willows which border it for hundreds of feet. The creek is only a baby here, scarcely three feet wide, and runs in* [a] *carefully stoned bed. It disappears into a tunnel under the railroad tracks at Overbrook station (thanks be to the poetically inclined person who perpetuated its memory in the name of the depot) and then, for all the long miles to the Schuylkill at Woodlands, it burrows foul and unpleasing beneath the surface.*

1850s	Beginning of West Philadelphia “streetcar suburbs.”
1866	Mill Creek surveyed to be drained

1869-1895	Construction of 6-meter concrete and brick pipe said to be the largest sewer pipe in the world.  1883 Photo
1930	Two injured when truck plunges into collapsed sewer, 43rd, south of Walnut.  1910 Map. Sansom-43rd-Walnut-44th block in green.
1930s	Homes collapse, Walnut between 43rd and 44th.
1945	Neighborhood of row homes destroyed.
1952	10-meter cave-in, Sansom near 43rd, swallowed car and delivery truck, along with front steps, porches and furniture. Car fished out. Truck never found.
1955	Roadbed undermined trolley crossing, Sansom between 43rd and 44th. Block condemned.
1958	Home collapse, Walnut near 43rd. One fatality.
1961	10-meter sinkhole, Funston near 50th and Parrish (2 kilometers upstream from the other locations). Three fatalities, including 9-year-old. City razed 115 homes and upgraded sewer. Muscatine Journal, July 18, "Philadelphia, PA House Collapses" *Four row houses, built over an antiquated sewer line collapsed Monday night, burying seven persons. Four were dug out alive, and practically unhurt. One of them a six-year-old girl, lay under the tons of rubble for nearly three hours. Many hours after the collapse which rocked the neighborhood, firemen searched the ruins for the other three.* *At 4:30 a.m., another neighboring house collapsed, imperiling firemen and rescue crews. But by then the occupants of that house had been evacuated together with about 600 other persons living in the same block.*

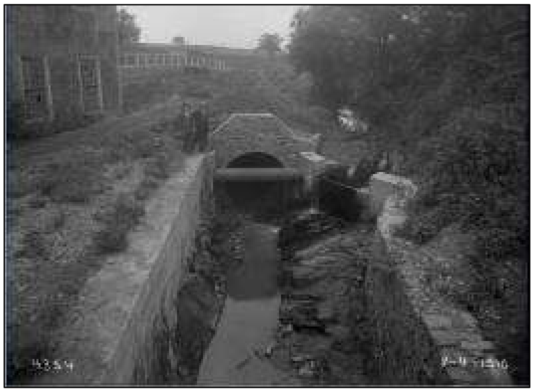
1961 (cont.)	Associated Press, July 18, *Firemen and other rescue workers use huge crane and shovel as they continue their search for at least three persons believed buried under the debris after a section of Philadelphia row houses collapsed. The house dropped into an underground creek used as a massive sewer.* 
1972	Cave-in, 43rd and Sansom. 116 evaluated. Sewer rebuilt.
Today	Supreme Supermarket parking, 43rd and Sansom

Streamflow that once powered mills above the surface can become a powered mole below.

Gunner's Run, North Philadelphia

Gunner's Run - named after a Swedish settler whose farmstead it traversed - drained almost all of Nicetown, Fairhill, Upper Kensington and Port Richmond.

We've no early photo of the stream, but it would have resembled Dobson's Run, the creek that drained parts of East Falls, Nicetown and Germantown.



Dobson's Run, 1910

Investors paid $100 a share in 1847 to convert the lower reach of Gunner's Run into an 8-kilometer canal, the Aramingo, but urbanization was soon weigh against the waterway.

> Capitalization was only sufficient to complete a quarter of the improvements.
>
> A slaughterhouse dumped carcasses into the waterway and within 20 years, the channel was inky black with a meter of ooze on the bed. In 1878, Gunner's Run was subverted into a 3-meter, 2-course brick channel, conveying 0.9 cubic meters/second in dry weather, and more after a rain. (Dobson's Run was likewise buried in the 1890s.)
>
> Water transport yielded to rail and roadways and the Aramingo was refilled between 1896 and 1902.

A waterway thus out of sight, out of mind, but like nearby Wingohocking and Mill creeks, not out of the ring.

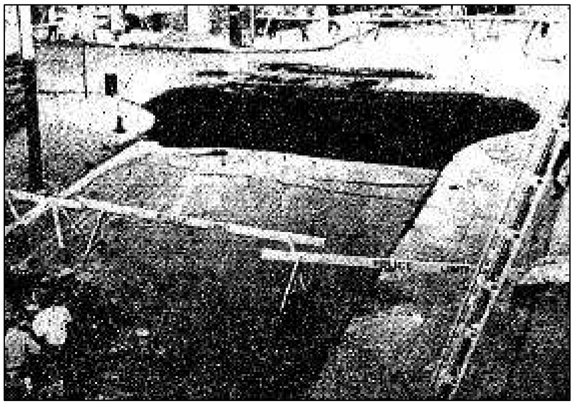
On August 1, 1959, 10:51 p.m., patrolman Joseph A. Reiss and his partner were called to check a pavement collapse at the intersection of Fifth and Clearfield. We'll follow the papers.

"Street Caves In, Hurls Policeman into Water," Los Angeles Times, August 2,

> *Reiss peered over the edge of the hole. Suddenly the edge crumbled and he plunged out of sight.*

"Policeman Lost in Street Cavern," Washington Post, August 3,

> *A policeman checking a cave-in at a street intersection last night was swallowed in a sudden collapse that left a hole 40 feet long and 40 feet deep. The accident apparently resulted form the crumbling of an old sewer line 30 feet below the surface of the intersection in northeastern Philadelphia.*
>
> *Water Commissioner Samuel Baxter said that the section was originally built on filled land over the Gunner's Run Creek and had a history of cave-ins.*



Baxter further elaborated that the calamity was due to the collapse of a 3.5-meter buried arch, a sewer structure built to support horse traffic, not trucks.

"Policeman's Death in Cave-in Feared," New York Times, August 3,

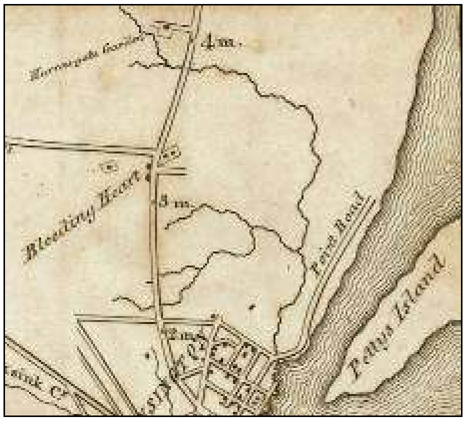
> *A gap 20 feet deep and 36 feet in diameter marked the spot where the officer disappeared.*

As the crater was elsewhere reported to be 43 feet deep, 60 feet long and 60 feet wide, it's difficult to be sure of its extent. Flooded cavities are more often measured by eyeball than by tape.

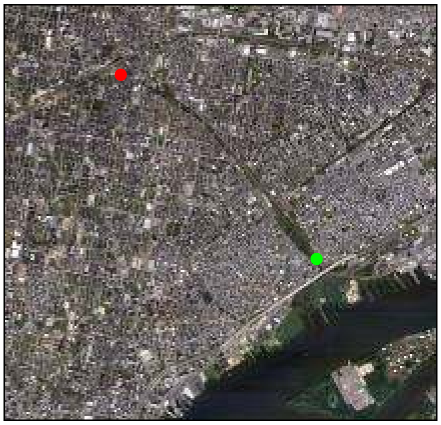
"Policeman's Body Found in Pit," Los Angeles Times, August 9,

> *The body of Patrolman Joseph Reiss was found at the bottom of a 40-ft. pit.*

On August 8, Officer Reiss's body was retrieved under the intersection of Richmond and East Somerset, some 3 kilometers from where he went down and less than two blocks short of being swept into the Delaware.



1892



● Cave-in ● Recovery of body

The speech by George Shotzbarger at the dedication of Patrolman Reiss's hero plaque, July 22, 2010, merits quotation.

> *On August 1, 1959, I was just a pint-sized 7-year-old, enjoying my carefree summer vacation, when Officer Reiss went down -- literally -- at 5th & Clearfield Streets.*
>
> *My father was walking my older sisters and me to 9 o'clock Mass on Sunday morning, August 2nd, when he figured out that something was very wrong. There was three times the normal traffic westbound on Indiana Avenue, as a result of the sewer collapse on 5th Street. Once we were in church, moreover, the old German priest asked all of Saint Bonaventure Parish to pray for "that poor policeman" who got caught in the terrible cave-in of the previous night. Needless to say, my dad stopped at the corner store and bought the Sunday morning paper to see exactly what had happened. The news was horrific, of course, and day by day it didn't get any better.*
>
> *For a young lad like me, it was the strangest, most memorable week: one "watershed" moment after another. For example, we weren't allowed to take collected newspapers to the junkman on the 31 hundred block of 5th -- which is how we used to earn our money for baseball cards, candy, and snow cones. We had to walk a different route to the pool at Mann Recreation Center, 5th & Allegheny. We remained on "close watch" outside our house, because the City decided to switch the one-way direction of traffic on 7th as a northbound detour to 5th Street, which would remain closed for months as the Streets and Water Departments repaired the huge sewer line and hole in the ground. The wives and women prayed and cried for Officer Reiss, his widow, and his children. And the men? Well, the men finally had something to talk about besides how much the last-place Phillies were stinking up the National League. There was, simply put, a new stink to discuss: even two blocks away, on certain days, we could smell the sewer water, especially because the collapsed cobblestones had effectively dammed up an underground stream, originally known as Gunner's Run.*
>
> *The grown-ups, however, wouldn't stop talking about Officer Reiss, and how it was such a damn shame that all those police, firemen, and sewer workers wouldn't just go down into that "culvert" and retrieve the dead cop's body. Misters Prouse, Forbes, Devine, Jones, Carr, Fedyna, Imwald, Rowan, Anderson -- all of them -- had been trained never to leave a brother-in-arms behind, but here the City seemed not to care about Officer Reiss enough to go down -- despite the risks -- and get him the heck out of there. They said they'd do it themselves, if the City would only let them. I can't know whether that level of neighborhood concern offers any consolation to the surviving family members of Officer Reiss here today, but the men in Fairhill were aghast at the eight days it took for the City to locate his remains.*

In Memory of
Police Officer
Died in the line of duty protecting
the citizens of Philadelphia on
August 1, 1959
Dedicated by his Family and Friends

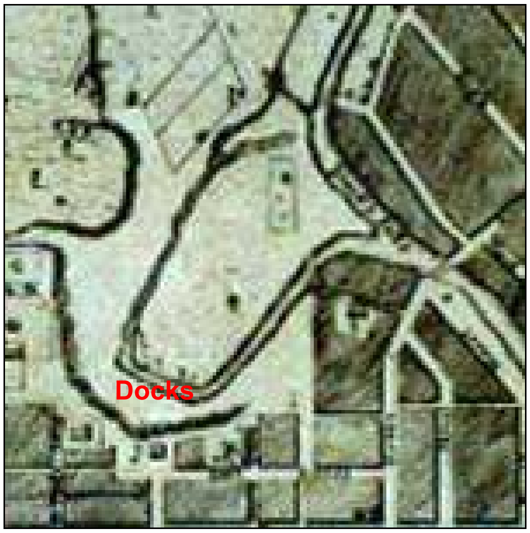
Fifteen meters of the Aramingo Canal's wooden wall were discovered in 2008 under the lattice of I-95 lanes. The long-forgotten Gunnar's Run had kept the wall waterlogged, sparing it from microbes that otherwise would have destroyed it.

Buried streams kill people, but then again, they can preserve wood.

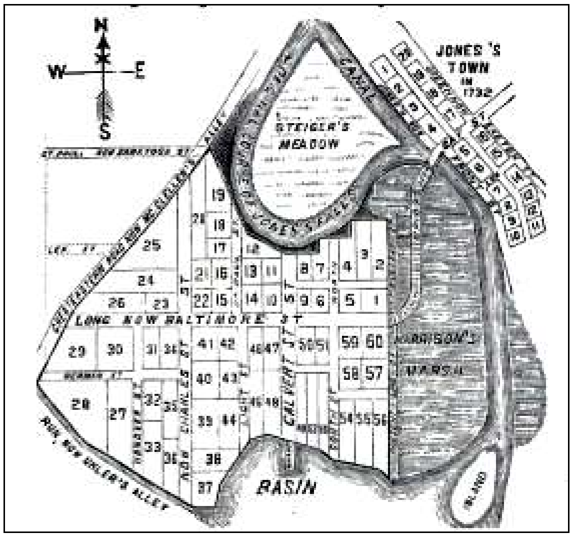
Jones Falls, Baltimore

Jones Falls River once horseshoed from where Baltimore's Gay Street crosses today's channel to where Battle Monument now stands, a bluff then 12 meters higher than today. The 25 hectares within the bend comprised what was known as Steiger's Meadow.

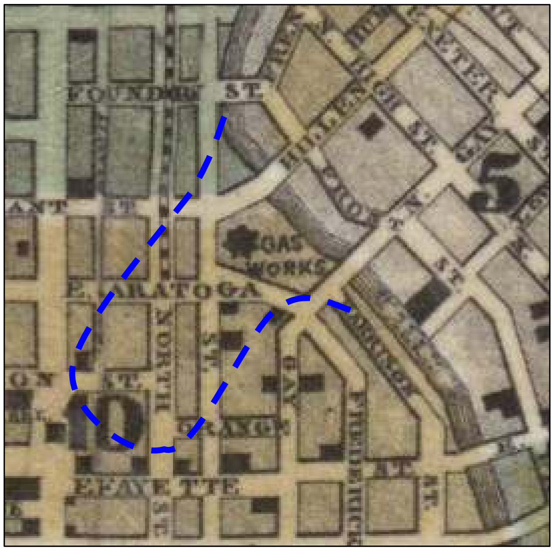
The meadow was drained in 1758 and converted into pasture. In 1789, a channel was sliced from Bath Street so the peripheral course could be filled and leveled for development.



1792


N
W
E
S
JONES 'S TOWN IN 1792
STEIGER'S MEADOW
CANAL
LONG NEW BALTIMORE ST
CALVERT ST
HARRISON'S MARSH
BASIN
ISLAND

Route of obliterated channel bend overlaid on 1853 map.

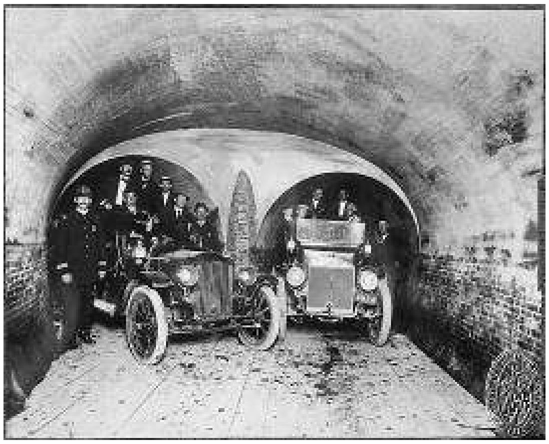


Baltimore was one of the last American cities to ban cesspools; there were 80,000 of them in 1879, most illegally overflowing into the storm-water drainage.

Raw sewage in Jones Falls gave Baltimore the highest typhoid rate of any city in the country.

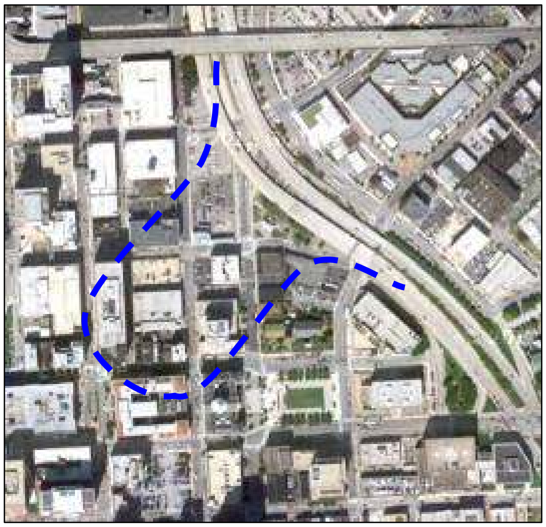
The Fallsway, a 6.5-meter diameter tunnel, was completed in 1916 to convey Jones Falls to the harbor.

“I’ve come to bury the Jones Falls, not to praise it,“ proclaimed the Master of Ceremonies before igniting the dynamite to Davy-Jones the polluted waterway.



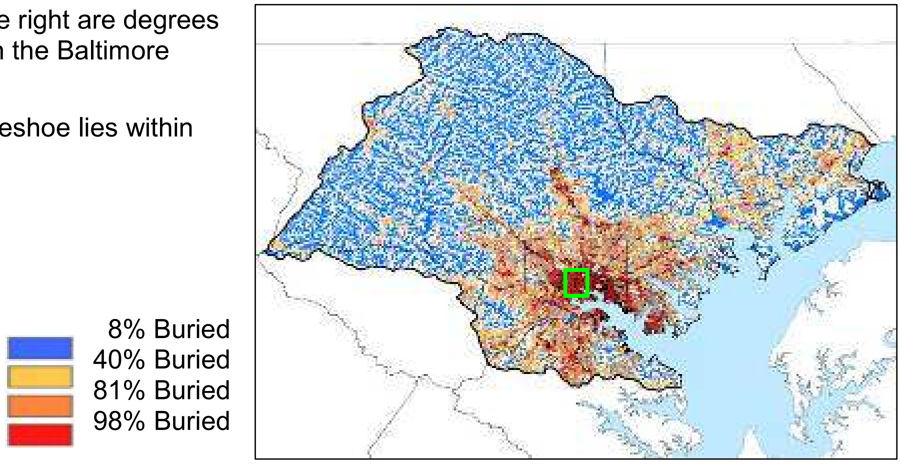
An automobile tour of Fallsway before it was opened to the river.

The Jones Falls Expressway opened in 1962, a torrent of traffic, not water.



For perspective, to the right are degrees of stream burial within the Baltimore watershed.

The Jones' Falls horseshoe lies within the green box.



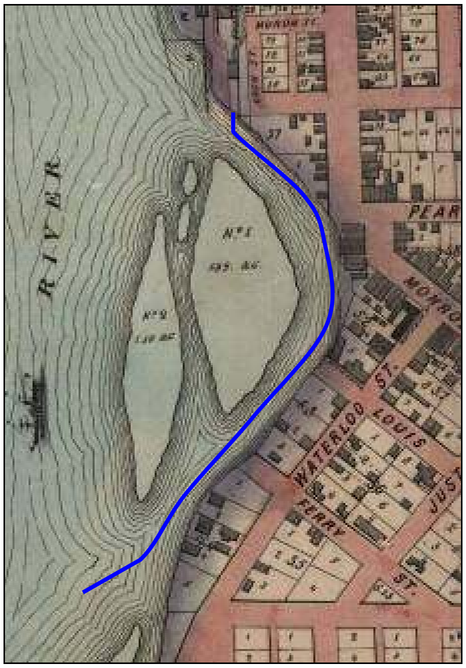
Unlike the three Philadelphia buried streams, here we've no fatalities, but there's been a price. Wrapped in sewer, water, gas and electric lines, the old Jones' Falls River Bridge can't be excavated from beneath the City Hall parking lot, precluding further development.

We can sometimes bury a channel easier than we can excavate its legacy.

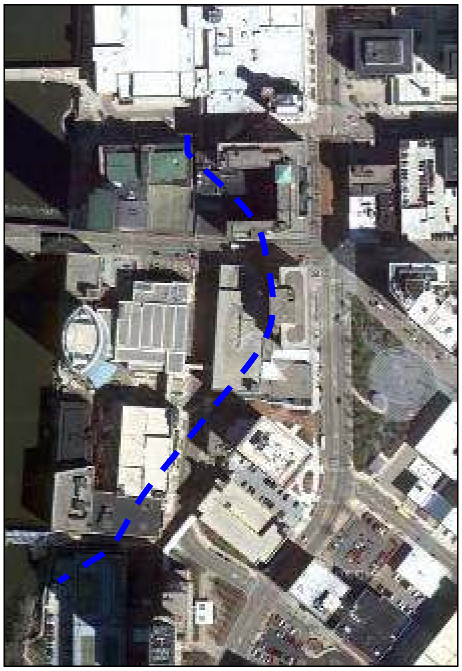
Grand Rapids, Michigan

A side-channel of Grand River once separated Islands No. 1 and 2 from the City of Grand Rapids, but with industrial development, the islands were merged with the mainland by boarding and bricking over the channel.

With time, however, the wood rotted and the bricks loosened. When the pavement collapsed in 1903, the underlying torrent was rediscovered, 3 meters deep and 4 to 6 meters across. As the gates to the forgotten channel had long ceased to function, a coffer dam was required to excavate a cavity 65 meters long, 6 meters wide and 7 meters deep for proper backfilling.



1853

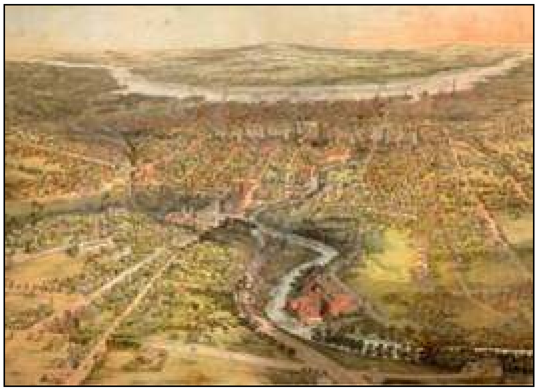


Today

Exhuming a subverted channel can be more arduous than its burial.

Park River, Hartford, Connecticut

Once called the "Little River," so as to not be confused with the Great (Connecticut) River, and later called the "Hog River" for its sewerage function during Hartford's pursuit of prosperity, Park River acquired its current name when Bushnell Park was created around it in the mid-19th century.



In the center, Park River, 1864

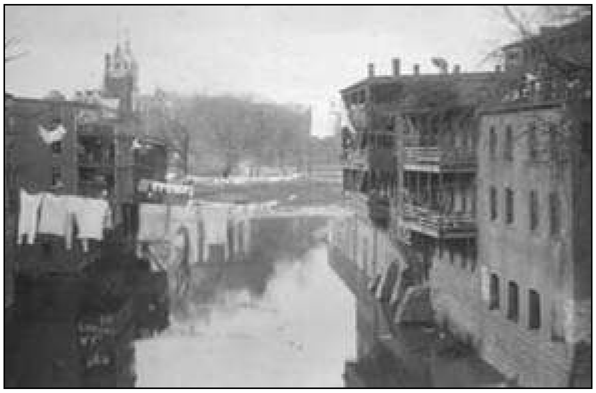
Park River through Bushnell Park

But, in fact, it never ceased being "Hog River." An 1880 resident complained that the waterway was “fed by fifteen sewers and drains, while three factories, a fish market and a dye house, and a score of tenements are constantly defiling its water with their refuse.”

From Report of the Board of Street Commissioners, Health Committee and Joint Special Committee of the Court of Common Council on the Park River Nuisance (1880),

> *It has been said that Hartford has no sewer system, but that seems to be an error, at least in part...*
>
> *Of the 8,358 acres within the city limits, 5,100 are comprised in the Park River basin, and the sewage from this section flows into the Park River through 29 sewers from 18 inches to 10 feet in diameter.*
>
> *The river forks at 13,889 feet from the Connecticut River, and from Capital Avenue to this point the water, though dark in color, seems free from odor, and not very foul; but in the North Branch, at the outlet of the Laurel Street (Noon Farm) sewer, the water is ponded by a bar which forms a natural dam, and there the pollution is apparent and offensive.*

Offensive, perhaps, but at least a place to hang the laundry.



1895.

1907

Through Bushnell Park, at least, the foul water was still scenic.

1909

A flood in 1936, “the greatest disaster that has ever befallen Hartford,” led to the formation of the Hartford Flood Investigation and Improvement Commission, a body ill-funded, but politically primed to respond to the hurricane of 1938, the “worst disaster” in the history of the city.

Roosevelt's New Deal had the funds and conversion of the waterway's lower 1.5 kilometers into a reinforced concrete conduit was approved by the Work Projects Administration within a week of the storm.

The river was run into twin tubes, roughly 9 meters wide and 6 meters high, under Commerce, Front, Prospect and Main Streets. The section under Bushnell Park, a 9x4 tunnel 10 to 15 meters below the surface, was covered by grass and a small pond. Construction began in September 1940 and was largely completed in November 1943.

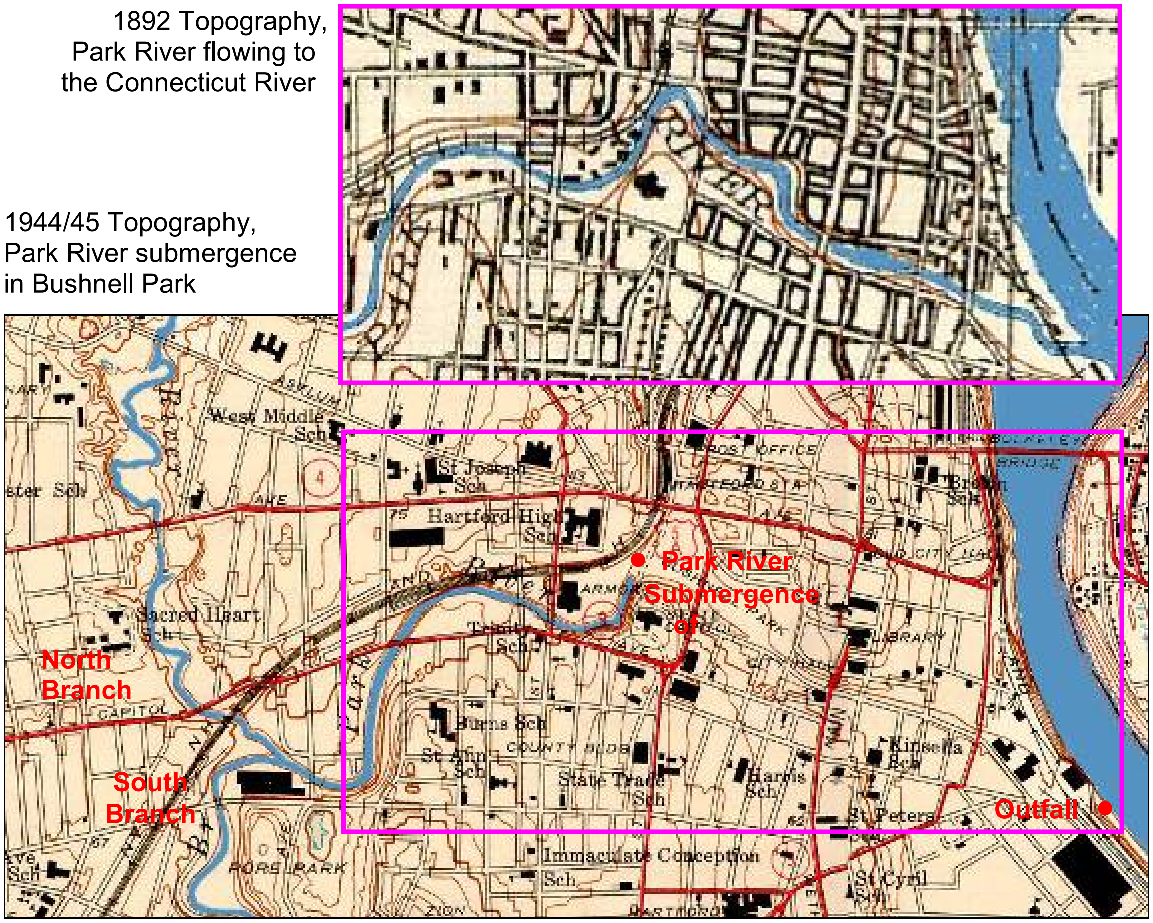
Construction on the first phase, 1941

Paving of the conduit top where a highway would eventually run, 1945

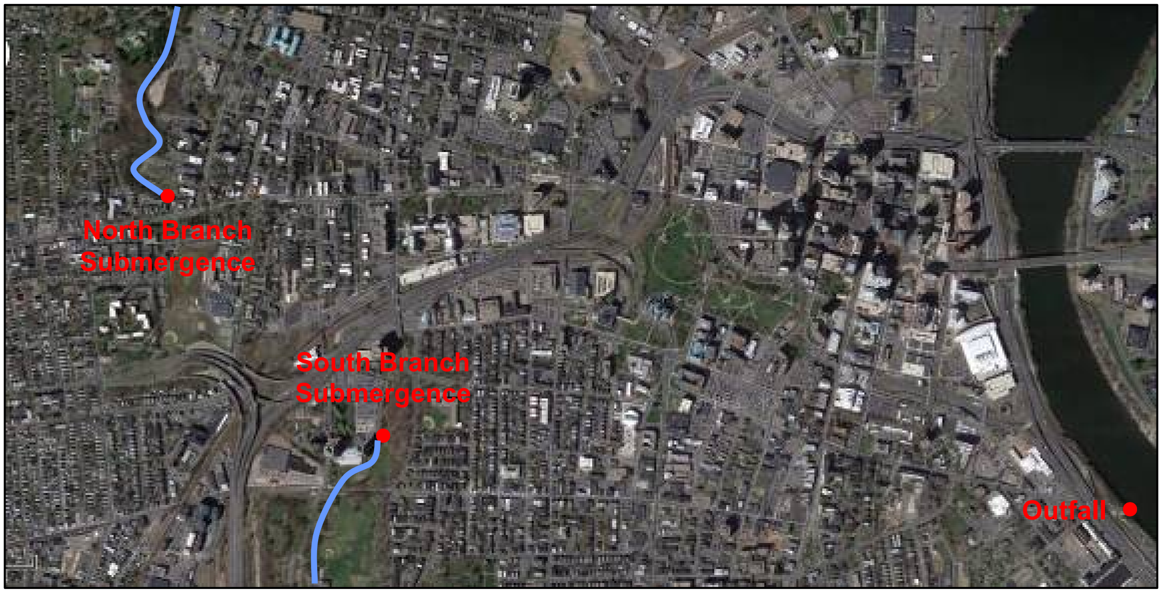
The subversion of Park River is chronicled in the maps that follow.

1892 Topography,
Park River flowing to
the Connecticut River

1944/45 Topography,
Park River submergence
in Bushnell Park


West Middle Sch
St Joseph Sch
Hartford High Sch
Sacred Heart Sch
Park River Submergence of
North Branch
South Branch
Trinity Sch
Burns Sch
St Ann Sch
County Bldg
State Trade Sch
Harris Sch
Kinsella Sch
St Peters
Outfall
Immaculate Conception Sch
St Cyril
Post Office
Bushnell Park
Brown Sch
Library
City Hall
Pope Park
Asylum
Capitol
Zion
Hartford

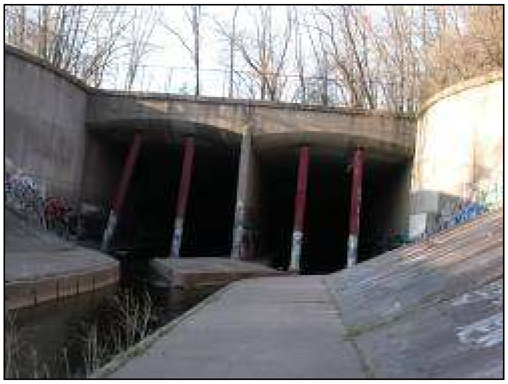
Below, the system today.


North Branch Submergence
South Branch Submergence
Outfall

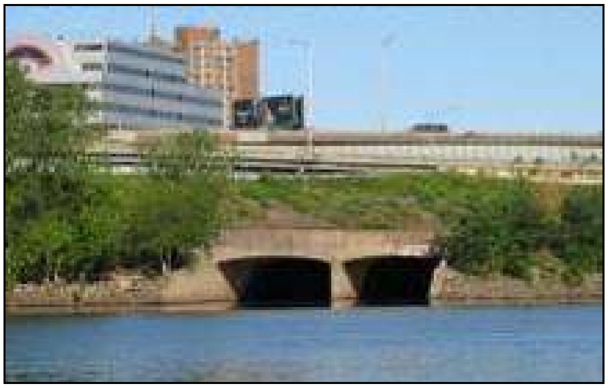
In 1966 the Corps of Engineers recommended yet more flood control and, as shown in the aerial photo, the covering was extended up the North and South branches in the decade following, making the burial 15 kilometers in total. Construction dewatering revealed a 3-meter dam composed of concrete blocks, truck tires, steel cables and other debris.

Today's subterranean channel is essentially a straight shot under the Capitol and Bushnell Park. Proceeding down the tunnel's length, one comes to a massive cavern where the two branches join and then split again into two parallel boxes to the Connecticut.

Above, the North Branch entrance near Woodland and Farmington Avenues. Mark Twain would have looked down upon this site from his mansion and seen the full swoop of the river.



South Branch entrance in Pope Park

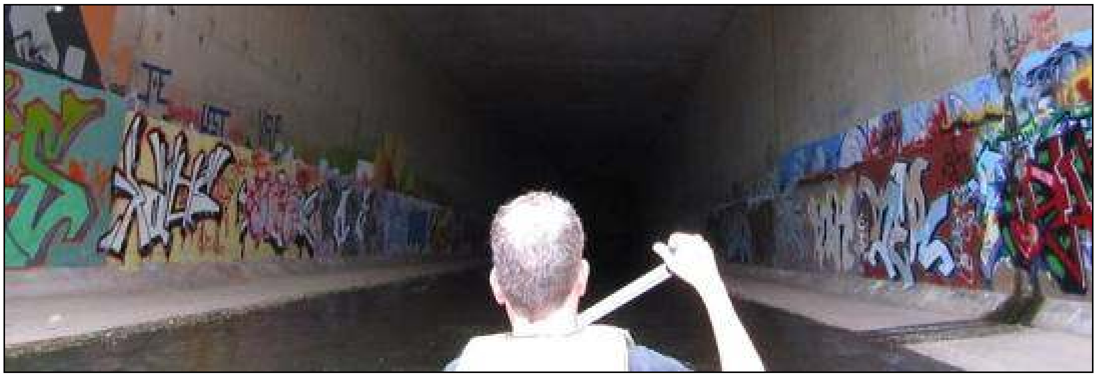


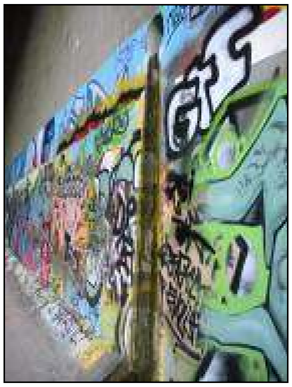
Outflow into the Connecticut River

Hartford formed a task force in 2004 to consider uncovering the channel, but after consultation with the Corps, the idea was deemed too costly. Chapter 85 discusses "daylighting" projects elsewhere where has succeeded.

Hartford's subversion of the Park River has worked in large part according to plan. The river has not flooded since 1955. Hartford encouraged industry to discharge waste into the Park's South Branch as late as that year, but with the advent of environmentalism, the waterway is at last reasonably clean.

Reqasonably clean, and somewhat of an art gallery, it seems.

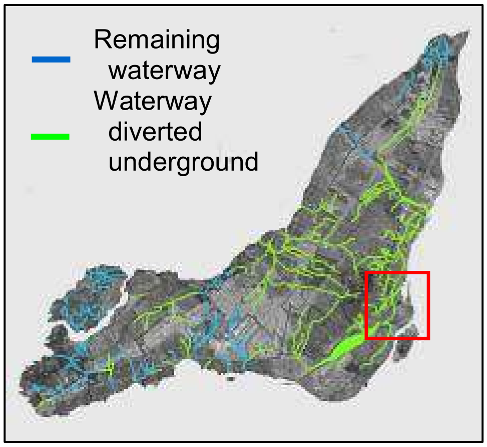


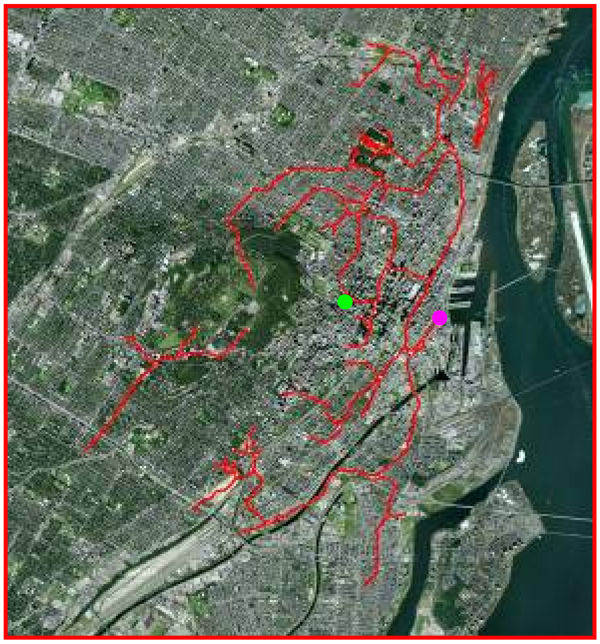


We'll have more to say in the chapter to follow about the legality of the canoeist in the top photo.

St. Pierre River, Montreal

In what's by now a somewhat familiar hydrologic sequence of urbanization, streams of Montreal Island have been likewise relegated to the underground.



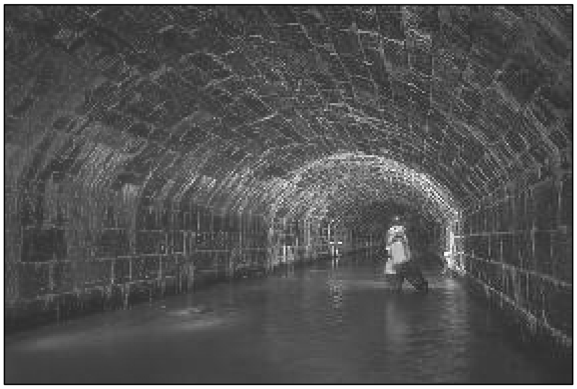


To the right,
Creeks prior to Montreal City urbanization
superimposed on modern aerial photo
● 2012 Sinkhole
● William Collector

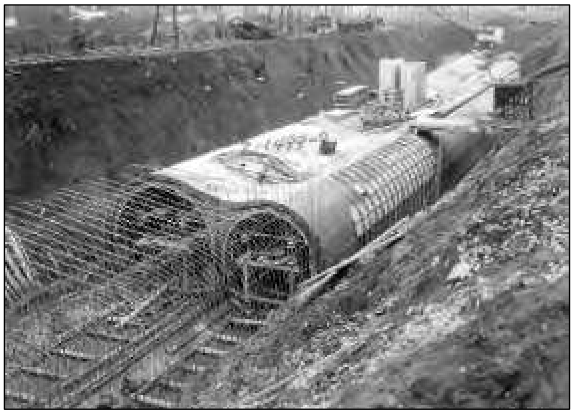
> *Near this Place Royale, there is a small river, which leads to some distance into the interior, alongside which are more than 60 arpents* [3.5 kilometers] *of land, which have been cleared and are now like meadow, where one might sow grain and do gardening.* --- Samuel de Champlain, founder of Montreal, 1611

Champaign's "small river" was the St. Pierre, the tangled red web on the aerial photo showing its drainage as pieced together from historical records, though it seems to have never been fully mapped. The circuit looped clockwise from the left-center to an outlet in the lower-right, inland of today's extended shore.

Montreal's first covered sewer, the William Collector, 4.25 meters wide by 4 meters high, was built beneath the city's old quarter in the 1830s to convey the polluted St. Pierre to the St. Lawrence.



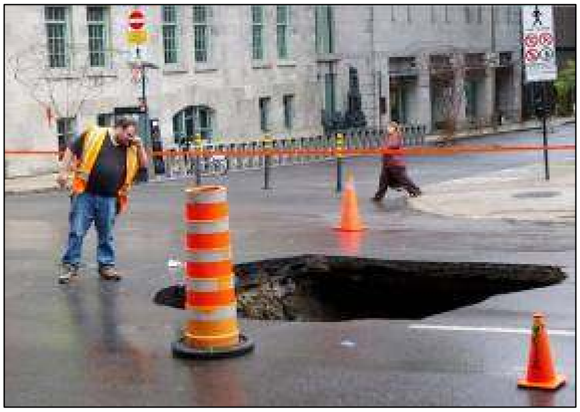
A century later, Montreal's aging collectors were systematically replaced by concrete conduits pursuing the expanding urban limits.



1933 Construction

The William Collector was pulled out of service in 1989 and partially backfilled in 1992.

Virtually no trace of the historic St. Pierre remains today, other than a diminished remnant of the branch along a parkway in the areal-photo's lower left.



The St. Pierre was thus removed from Montreal's mind until it regained a few days of daylight in May, 2012, via a 4-meter-diameter, 6-meter-deep sinkhole in Sherbrooke St. The street collapsed just hours after tens of thousands of students protesting tuition hikes and demonstration restrictions had marched over it.

But there is -- or at least promises to be -- an illuminated future for the William Collector.

Pointe-à-Callière, Montreal's Museum of Archeology and History, will convert one kilometer of the sewer into the spine of its complex, the longest underground exhibit in the world.

Pointe-à-Callière
$18.00

Future World Record

Longest Underground River to Museum Conversion
1 kilometer

Dry Run Creek, Waterloo, Iowa

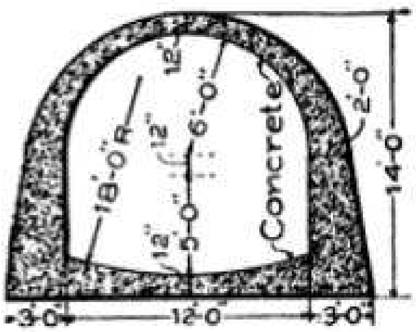
Dry Run Creek flowed through Waterloo from marshes west of city to the Cedar River, but as evidenced by a "A Fearful Deluge" in the Waterloo Courier, July 14, 1880, it wasn't always dry.

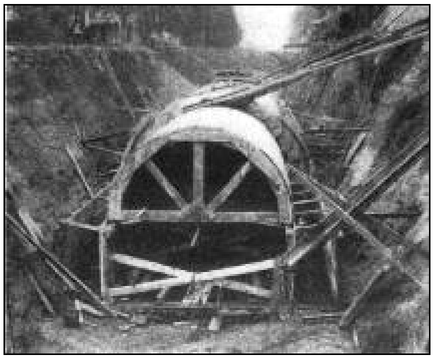
> *A Dry Run becomes the Bed of a Mighty Torrent which Floods the West Side! Alter the Waters Subside Six Lives are Lost -- Full Particulars of the Terrible Affair -- List of Losses, &c., &c.*
>
> *At almost three o'clock last Sunday morning an alarm was given from the Red Jacket engine house which soon called out the entire fire department, who found out that instead of having to fight fire, their assistance was needed to aid in the rescue of life and property threatened by a sudden rush of water from the dry run which passes through the second ward.*
>
> *The run is probably the bed of some ancient stream. It extends out into the country several miles where it drains an extensive area from which during heavy rains a large amount of water is collected, with no other outlet except to the river through the city.*

When in 1902, the creek twice rose 3 meters within a few minutes and flooded the city's business district, the citizens resolved to contain the channel.

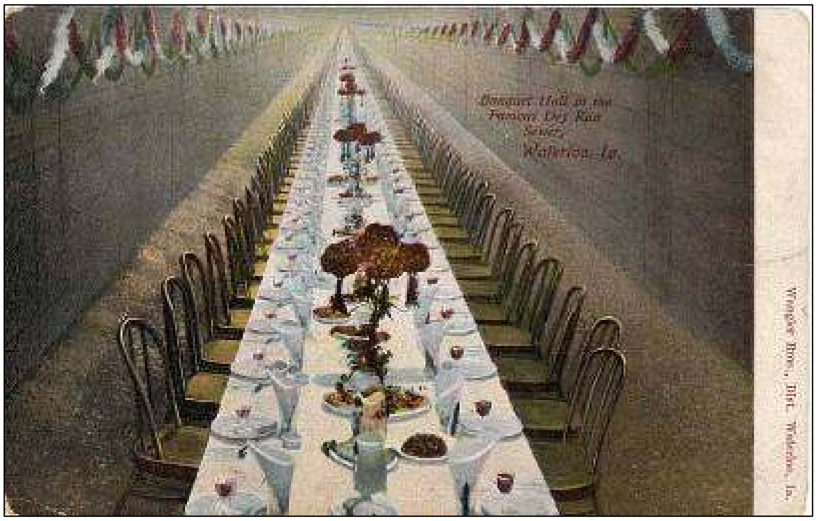
"A Flooded Street in Waterloo, Iowa, Where the Great Urban Drain Was Constructed," The Strand Magazine, February 1904

Contain it they did, subverting the flow into 1000-meters of conduit, its 3.5 square-meter cross-section dwarfing the natural channel.





To celebrate the work's completion, the Iowa League of Municipalities held its 1903 banquet within the conduit. Four-hundred formally-attired dignitaries descended a staircase between Randolph and Wellington Streets into a sewer section containing a banquet table 125 meters in length.


Banquet Hall in the Famous Dry Run Sewer, Waterloo, Ia.
Wengert Bros., Mfrs. Waterloo, Ia.

"Banquet Hall in the Dry Run Sewer, Waterloo, Iowa." a period postcard

The October 15, 1903 edition of the Waterloo Daily Reporter hailed the feast as a "Grand Success. Visitors Went Away Well Pleased." A few excerpts:

> *Most Beautiful Sight. A number of powerful arc lamps were strung about the banquet hall entrance which was elegantly decorated with evergreens and bunting, flags, etc., giving the exterior a magnificent appearance. As one actually entered the sewer, however, the view was long to be remembered. Not one of those in attendance had ever before witnessed such a dazzling sight and without exception the visitor would remain standing on the final flight of stairs to obtain a good view of the long table and banquet hall.*
>
> *Because of the limited capacity of the hall, the first course of oyster cocktail, etc., had already been placed on the table before the visitors were seated. The balance of the courses, however, were all served and in the best manner, although the space left for attendees to pass through the files of those seated was comparatively small.*
>
> *Dry Run Punch, a delectable dish, attracted no little attention.*

Indeed it must have, as the toasts lasted 90 minutes.

Apollinaris Oyster Cocktail
Kennedy's Wafers

* * *

Escalloped Oysters
Celery

* * *

Cold Roast Turkey Cranberry Sauce
Mashed Potatoes, Brown Gravy
French Pea Patties

* * *

Soterian
Vienna Bread Parker House Rolls

* * *

Dry Run Punch

* * *

Sliced Cold Tongue Pressed Veal Loaf
Sliced Ham
Olives Radishes

* * *

Fruit Jelly

* * *

Colfax
Lobster Salad Waldorf Salad
Wafers Salter Almonds

* * *

Ice Cream, La Rose
Devil's Food Angel Cake
Macaroons Kisses

* * *

Cigars
Pineapple Cheese Roquefort Cheese
Dent's Water Crackers

* * *

Coffee

> *Placed at each place of the banquet table was a souvenir glass containing cigars and matches. The glasses bore an appropriate inscription and in each case were carried away as a remembrance of the banquet. The menu cards were also preserved by those attending and the thoughts of the sewer banquet will linger long in the minds of everyone who has actually eaten in a sewer.*

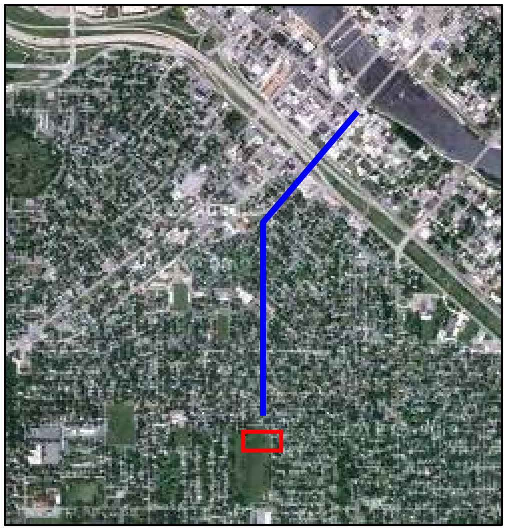
Scott Beason, "the well-known Illinois Central official," remarked,

> *I have attended banquets in New York, Chicago, the west, north and south, but never in my life have I enjoyed an affair of that kind more than I did last evening. Waterloo people can now hardly appreciate the value of such a unique event. It was great.*

The cost was $3 a plate, pricy, but two weeks later for just $0.25, the ladies of the Progressive Brethren Church offered their own dinner from the same table. Not the same bill of fare, of course, but including "oysters, coffee, cold meats and the usual accompaniments" and free of speeches. "All are invited."

Newspapers around the world carried the story of the magnificent banquet, the October 15 New York Times headlining, "Banquet Given in a Sewer, League of Iowa Municipalities Entertained in the Storm Drain at Waterloo,"

Dry Run has since been further enclosed, and had the structure not hosted the famous celebration, it would be just another urban creek-to-sewer conversion.
To the right, the route superimposed on a modern aerial photo. Below, the entrance at Liberty Park -- the 1903 starting point.



In the late 1960s, firemen were again called for a Dry Run rescue, but this one for a youth stranded in the concrete tract during an unanticipated rainstorm. He was attempting to become one of the few to take the great Waterloo underground express all the way to the Cedar River.

Cedar River levees suffered some damage, but held back most of the record floodwaters of June 2008, according to the Army Corps of Engineers, Rock Island District.

> *The system of levees, floodwalls and closure structures performed remarkably well, especially considering the severity of the event. Flooding in the city of Waterloo was mainly due to the inability to close off gatewells along Dry Run Creek in the westerly downtown area and due to the inability to effectively close off railroad and road gate closures along Black Hawk Creek.*

Apparently no one at City Hall was aware of the arch gate where Dry Run connects to the Cedar and its closing mechanism had rusted in place.

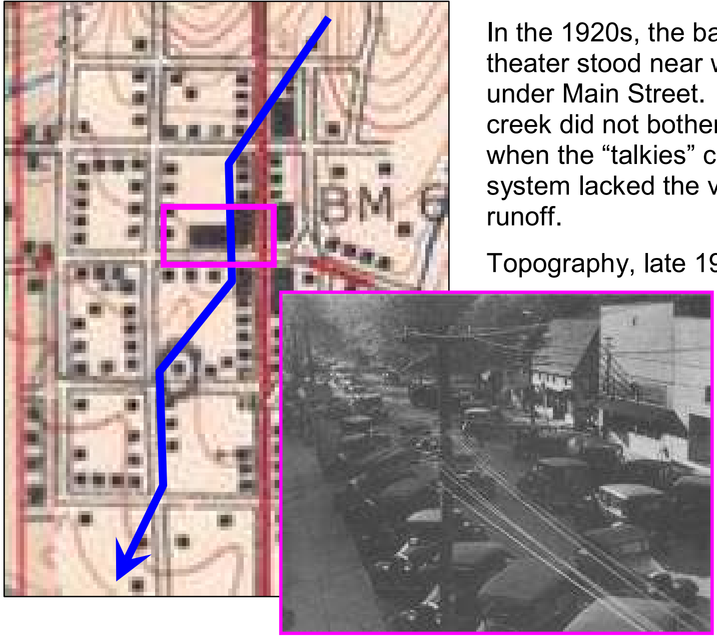
> *Due to the flooding event, the closure gate to Dry Run Creek needed to be closed. Upon further investigation, this gate closure was not listed in the (operation and maintenance) manual for the project and was not maintained by the city since construction of it was completed in 1986.*

A dual legacy for Dry Run, it seems:

> An epicurean event more splendid than that at any other underground river.
> A forgotten flood gate.

Nashville, Indiana

In the early 20th century, a small stream was confined in a 1.5-meter-diamter sewer for portions of its brief passage through Nashville, Indiana, by all measures a small-town story compared to the urban works of Philadelphia, Baltimore, Hartford and Montreal.



In the 1920s, the back of Nashville's movie theater stood near where the conduit passed under Main Street. Noise from the hidden creek did not bother silent moviegoers, but when the “talkies” came in, the primitive sound system lacked the volume to compete with the runoff.

Topography, late 1940s

Photo, by location, showing the cinema, 1927.

Let Us Not, However, Always Blame a Buried Stream

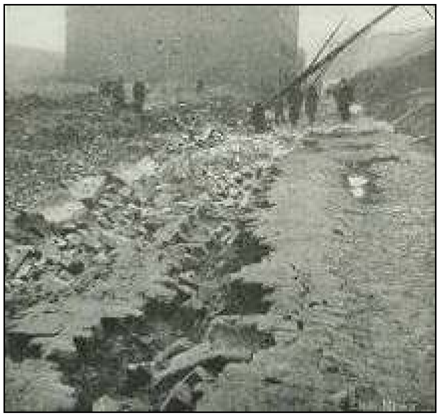
Streets can collapse for reasons other than being above a waterway.

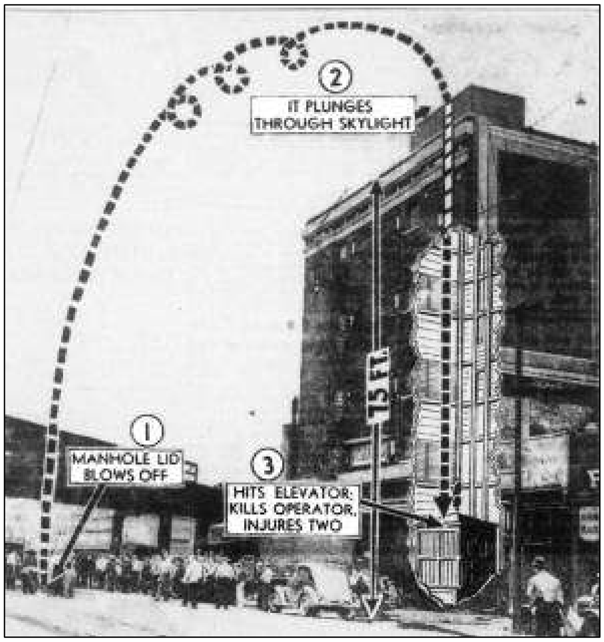
Progressive erosion of backfill around even a minor pipe leak is well-documented. Popular Mechanics, June 1923, "Leaking Sewer Wrecks City Street," features a Philadelphia sinkhole caused by leakage erosion.

> *The noise of the cracking of the slab before it collapsed averted possible loss of life, warning, as it did, a number of boys who were playing in the street.*"

Urban structures can be built over karst sinkholes-to-be (Chapter 40). The Springfield, Missouri street just happened to be in the wrong place.

Unventilated sewers can explode.





②
IT PLUNGES THROUGH SKYLIGHT
75 FT.
①
MANHOLE LID BLOWS OFF
③
HITS ELEVATOR; KILLS OPERATOR, INJURES TWO

Above, "The Pittsburgh Sewer Explosion," Engineering News, January 1, 1914

To the right, "One Killed when Blast Flips Manhole Cover," Chicago Tribune, May 30, 1937

Leakage, solutioning and gas accumulation can cause sewers to fail, but when sewers misbehave, be sure to consult the pre-development maps.

CHAPTER 77

ACCESS TO UNDERGROUND RIVERS

Some may suppose that the greatest impediment to underground river access relates to physical safety, but that's not necessarily the case. The greatest impediment is frequently the law.

As we will see, the law applicable to underground river access varies between jurisdictions, but in large part, the legal principals are similar.

Criminal Mischief

Keeping in mind that a sewer is one form of an underground stream (Chapter 58), we begin our legal primer with a case of alleged underground river mischief. On Easter weekend, 2010, journalist and urban underground explorer Andrew Emond and photographer Michael Cook were arrested during a foray into the Toronto storm sewer labyrinth.

A passerby spotted the head-lamped and hip-wadered culprits entering the sewer system and called police, who showed up with four fire trucks and a hazardous materials team.

Four hours later, Cook and Emond were arrested for "mischief to interfere with property."

Garrison Creek Reserve Sewer in which the two were apprehended. Photo by Andrew Emond.

Toronto Police Detective Dan Hoffmeyer said that storm sewers can be dangerous.

> *Down there, there's poisonous gasses. Hazmat crews here go down with breathing apparatus, or they just* [send] *down* [a] *video camera. They don't go down personally.*
>
> *There's* [also] *a chance of the tunnel filling up in a matter of minutes and people drowning. If there was a storm somewhere, they'd fill up in a matter of seconds.*

"Mischief to interfere with property," per the Canadian Criminal Code 430(1), applies when someone willfully:

Destroys or damages property.
Renders property dangerous, useless, inoperative or ineffective,
Obstructs interrupts or interferes with the lawful use enjoyment or operation of property, or
Obstructs, interrupts or interferes with any person in the lawful use, enjoyment or operation of property.

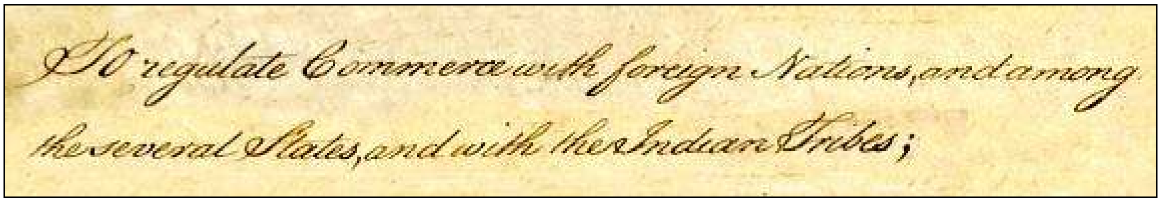
One suspects that the authorities were overplaying their hand in an attempt to discourage sewer exploration. The public, who enjoyed Emond's urban-adventure travelogues, was displeased and the charges were dropped.

Federal Navigability

The larger portion of this chapter deals with "navigability," a judicial determination that can enhance public access to a waterway. Physical "navigability" allows a cave to be explored by boat -- generally more easy than by foot -- but legal "navigability" may determine if the cavern can even be entered.

To make sense of the law regarding travel upon water in the United States -- on the surface or below, the legal issues are much the same -- we turn to the common law Doctrine of Public Trust, government's right to hold certain resources for the benefit of the general public. Streambeds of “navigable” waters in the United States thus belongs to the federal government and jurisdiction over such waters -- how the waters are used, by whom, and under what conditions -- is a federal prerogative. It's generally legal for the public to navigate upon such streams if it can be done without trespassing on private land.

The key term is “navigable.” and here we enter a spectrum of legal definitions stemming from Article I, Section 8, Clause 3 of the United States Constitution, the Commerce Clause.



To regulate Commerce with foreign Nations, and among the several States, and with the Indian Tribes;

The federal government gets first crack at the meaning of "navigability," its interpretation derived from an 1870 federal court ruling oddly known as ***The Daniel Ball***.

> *Those rivers must be regarded as public navigable rivers in law which are navigable in fact. And they are navigable in fact when they are used, or are susceptible of being used, in their ordinary condition, as highways for commerce, over which trade and travel are or may be conducted in the customary modes of trade and travel on water.*

Lakes and large rivers having an historical record of commerce are indisputably subject to federal regulation because as the Supreme Court has repeatedly held, “rivers that are navigable in fact are navigable in law.” But smaller water bodies may also qualify by any of a 1979 Supreme Court set of tests.

Waters of navigable capacity,
Waters subject to tidal ebb and flow, or
Waters connected to a continuous interstate waterway,

Federal agencies can further interpret “navigability” for their own purposes, and such agencies are prone to interpretations that increase their authority. In enforcing the 1972 Clean Water Act, the Environmental Protection Agency interprets "navigability" as,

Waters navigable in fact, or
Watercourses having "a significant nexus to navigable waters."

This "nexus" criteria was immediately taken by wags to be that of "being capable of floating a legal document," but the EPA has come to construe the test more narrowly. A watercourse not navigable in fact can be considered "navigable" only if it possesses a "significant nexus" to waters that "are or were navigable in fact or that could reasonably be so made."

As "nexus" means "connection or series of connections linking two or more things," a "significant nexus" would be direct, indisputable water-to-water linkage.

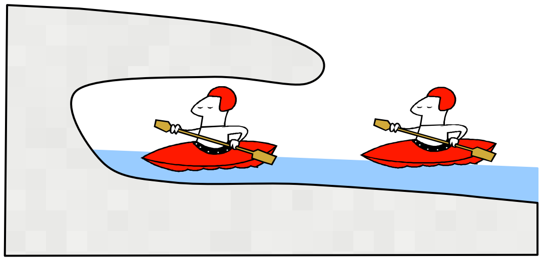
To the EPA, a small watercourse may thus be classified "navigable" if it flows directly into a watercourse that is navigable in fact. "Mere hydrologic connection," does not necessarily satisfy the test.

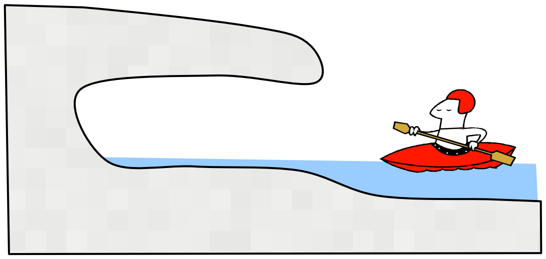
Subterranean streams that would likely be deemed navigable by the EPA nexus test:

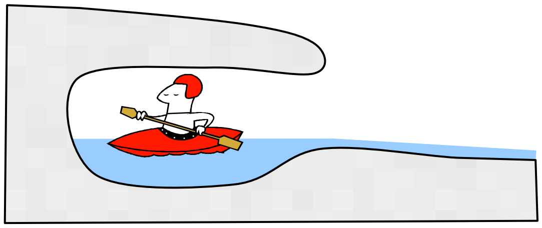
An underground segment of a stream that alternates between navigable surface segments and subterranean segments.

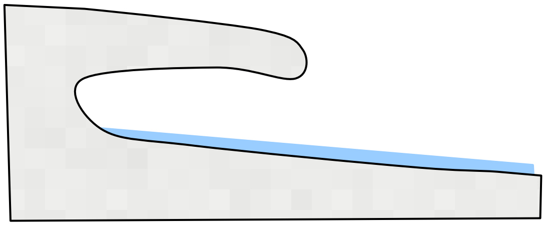
A cave river flowing directly to or from an external navigable waterbody.

Of the four examples below, only the cave on the lower-right appears not within EPA jurisdiction.









Designation of a waterway as "navigable" for purposes of water quality control, however, doesn't in itself make the waterway "navigable" per the Commerce Clause, and thus there should be no presumption of public access.

The federal government retains authority over (and under) lands which it owns. Echo River in Mammoth Caves National Park is thus subject to National Park Service jurisdiction. We're not aware that anyone has sued to re-launch that river's boat ride (Chapter 50), but if it were done, the challenge would be in federal court and would deal with the impact of the closure, not the NPS authority to make the decision. That the Echo happens to be subterranean would be inconsequential to the judge.

Federal regulation of waterway accessibility can be summarized as follows:

> Determination of "navigability" is made, based on interpretation of the Commerce Clause, which -- as might be expected -- largely deals with commercial carriage. Waterways passing this test tend to be large, often with long histories of shipping.
>
> If the waterway is found to be navigable, the federal government owns the streambed and the public tends to have substantial rights of access, though certain agencies can curtail uses in accord with the agency's charge.
>
> If the waterway is found to be non-navigable, or if the federal government refrains from making the determination, the states decide.

State Navigability

Absent federal pre-eminence, the state can undertake steps similar to those above or it can establish its own determination of waterway accessibility. In many cases it is the former, often with a somewhat relaxed standard of navigability which brings smaller waterways to state ownership.

State constitutions are prone to assert that “all surface water” is owned by the state for use by the public. In Montana, "all surface waters that are capable of recreational use may be so used by the public without regard to the ownership of the land underlying the waters." But do such "surface water" references imply that all waters not on the surface are subject to other law?

Probably not.

Unlike the distinction between streamflow and percolating groundwater (Chapter 63), the record of cave river litigation has tended to regard cave water as a channelized stream, not diffuse groundwater. The law regarding cave rivers is the law regarding rivers in general, law in which navigability plays a significant role.

As no two states approach the question of waterway access in identical manner, similar waterbodies may be deemed publically accessible in one jurisdiction, but not so in another. In states where "navigability" is difficult to prove, riparian landowners tend to retain property rights to -- and control over -- streambeds that in other states might be held in public trust.

We'll begin with a rough split of the states into those in which laws and judicial decisions suggest that a case for public access would seem to have a sound footing. As any particular outcome depends on the facts and arguments, we'll not suggest that our list foretells the ruling, but were we the party seeking access, we'd rather be in the list.

States in which public access to cave rivers may have strong legal basis

Alaska
Arkansas
California
Hawaii
Idaho
Indiana
Iowa
Maine
Maryland
Minnesota
Mississippi
Montana
Nebraska
New Mexico
New York
North Carolina
North Dakota
Ohio
Oklahoma
Oregon
South Carolina
South Dakota
Tennessee
Texas
Utah
Washington
Wisconsin
Wyoming

A few examples

Arkansas, **Idaho**, **Maine**, both **Carolinas**, both **Dakotas** and **Tennessee** employ the "recreational boating test" as pro-forma proof of navigability. If a boater can float the river, it's navigable. In South Dakota, for example,

> *The people of the state have a paramount interest in the use of all the water of the state, and that the state shall determine what waters of the state, surface and underground, can be converted to public use or controlled for public protection.*

Idaho is one of the more boater-friendly states in the nation. Channels floatable by kayak are open to the public for any recreational purpose, including scouting and portage.

Texas considers watercourses to be navigable when they are "capable of being used in their ordinary condition as highways for commerce over which trade and travel may be conducted in the customary modes of trade or travel on water." Such capacity must

Result from natural causes,
Ordinarily recur from year to year, and
Persist for a sufficient duration to be useful as a highway.

A body of water is useful to the public if it is used for pleasure boating, hunting or fishing.

A Texan's right of free passage in such streams includes the right to pleasure boat and fish. As the beds of navigable rivers are owned by the state, wading is permissible. The right of portage around natural obstructions, however, is doubtful.

A Texas watercourse having an average width exceeding 30 feet to the mouth is considered to be navigable, regardless of use. While Texas caves contain isolated pools of this size, none, however, are a watercourse of that dimension to the cave mouth.

Waterway width is measured at the ordinary high water line, the line between land that is affected by water discharge and land that is not. Below the line, the surface is sand, gravel, rocks and aquatic vegetation; above the line is soil. Gravel bars and sandy beaches formed by frequent river deposition are by definition within the ordinary high water line. As cave beaches may be the undisturbed artifacts of higher flows millennia earlier, however, the modern ordinary high water line would be that evidencing geologically-recent sediment transport.

A **Wisconsin** court has interpreted the navigability test to be satisfied where "a stream is capable of floating any boat, skiff or canoe of the shallowest draft used for recreational purposes." The period must

> Regularly occur, and
> Last long enough to allow recreation.

Navigability in an artificial channel not connected to a natural stream or lake, however, does not by itself create or enhance public rights. The rights of the public include recreational enjoyment of the waters, which encompasses fishing and boating. Wading and touching the bottom is generally permissible as an incident to navigation.

California and Oklahoma define navigability as the capacity to float an oared craft such as a kayak or canoe, though differences exist regarding the right to use the bed for anchoring, standing, or other purposes.

Oregon and **Washington** define navigability as the capacity to float shingle bolts. While we can imagine Northwestern cave explorers packing cedar shingles into a flooded cavern to prove it navigable, we find no record of such in court records.

Postcard, Shingle bolts boom on on Skagit River, Washington.

The only **Hawaiian** island having streams navigable-in-fact is Kauai and very little law deals with public rights in those streams. Little law likewise discusses the public right to recreate in non-navigable rivers. State statute provides that

> *Springs of water, running water, and roads shall be free to all, on all lands granted in fee simple; provided that this shall not be applicable to wells and watercourses, which individuals have made for their own use.*

Hawaiian law requires lava-tube travelers to secure permission from land owners along the route, but a sea cave can be kayaked as far as one can penetrate.

States in which public access to cave rivers may have weaker legal basis

Alabama
Arizona
Colorado
Connecticut
Delaware
Florida
Georgia
Illinois
Kansas
Kentucky
Louisiana
Massachusetts
Michigan
Missouri
Nevada
New Hampshire
New Jersey
Pennsylvania
Rhode Island
Vermont
Virginia
West Virginia

A few examples:

Colorado, **Kentucky** and **Michigan** have explicitly rejected the "recreational boating test." The fact that a boater can float a river does not prove it navigable.

Arizona and **Nevada** deem their respective portions of the Colorado River to be navigable, but their internal waterways to be non-navigable. If one owns the land upon (or under) which a stream flows, one owns the waterway. Whether one can divert or consume that water is, of course, a different question.

Georgia's view of navigability is perhaps the nation's most restrictive. A navigable stream must be capable of transporting boats loaded with freight in the regular course of trade. State courts have even defined the length (200 feet), width and draft of barges required under the test. Mere rafting of timber or the transporting of wood in small boats does not make a stream navigable. Furthermore, the publics' rights in navigable rivers to wade, fish and portage only extend to the ordinary low water mark.

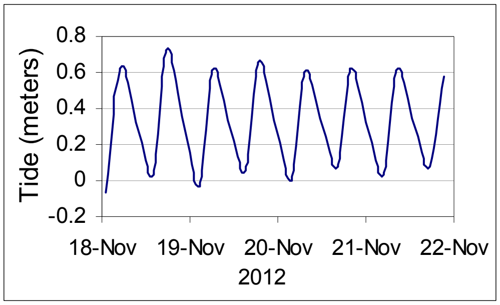
We described the enclosure of Hartford **Connecticut's** Park River in the previous chapter and now we'll consider an attendant legal question -- does relegating a navigable river underground render it non-navigable?

The Connecticut public has the right to boat, hunt, and fish in "navigable waters which are physically capable of supporting waterborne traffic, and subject to the ebb and flow of the tide."

Connecticut case law has imposed an additional requirement.

> [Such] *water* [must be] *navigable for some useful or valuable purpose... There must be some commerce or navigation which is essentially valuable... A hunter or fisherman, by drawing his boat through the waters of a brook or shallow creek, does not create navigation.*

The tidal influence on the Connecticut River at Hartford is illustrated by a snippet of its stage.



Park River was found to be likewise navigable in Edward Balf Co. v. Hartford Electric Light Co., 1927, albeit before the stream's covering in the 1940s, but tidal action doesn't cease because of darkness.

John Kulick of Huck Finn Adventures used to make the three-hour suburban Park River canoe trip almost daily with groups of about 10 clients. That Kulick derived $55/head from the tours would seem to satisfy the commerce aspect.

Huck Finn Adventures
Come paddle with us!

Kulick received informal permission from the city in 1997 to do so, but the city then reneged, saying that possible gas leaks, sewage and the difficulty of rescues created liability.

Kulick argued that the ventures were safe and that his insurance would protect the city from claims. After officials took the trip in 2003, the council voted 5-4 to allow him to resume business, which he did until the city's counsel, John Rose, intervened. A covered waterway is no longer a "normal river," according to Rose, but a dangerous place of "controlled access," like a bear cage at a zoo in a public park.

> *If you ask Fire Chief Teale, he'll say within 50 yards of entering the tunnel there is no communication with anyone but God. If somebody has a heart attack in there, they'll die.*

That the city had pondered the issue for years would make it all the more liable for knowingly allowing the trips to continue.

Kulick said the city should partner with him because his knowledge of the subterranean reach could help the fire department understand rescue issues and flood control authorities identify debris. He continues to view the underground river as a natural resource, telling the New York Times, July 31, 2003,

> *We've seen eels, carp, stripers, just like you would in a normal river. If you point your headlamps into the water, you'll more than likely see a fish.*

According to Curt Johnson of the Connecticut Fund for the Environment, the court ruling designating the Park as "navigable" subjects it to public access requirements. Without subsequent law giving the city additional authority regarding the underground portion, the earlier designation holds sway.

> *Even if it was the city of Hartford that had put a conduit on this, it doesn't magically transform this river into an ownership right to the city.*

Austin Carey, another environmental lawyer, suggested that it might be up to the state, rather than an individual, to force Hartford to recognize the right of public access.

> *There's a good argument that the city is trying to interfere with the right of navigability. Who can enforce that is a different equation. There might be changes in the law that allow an individual to try to enforce that right. Or John Kulick could go in the river and try to get himself arrested, and let the city try to prove he did something wrong.*

Huck Finn Adventures remains yet prohibited from the very river that Mark Twain overlooked as he wrote of Huck's adventure on a larger waterway. The question of which government makes the Park's navigability call remains unresolved and Kulick remains busy where whitewater is white.

Trespass

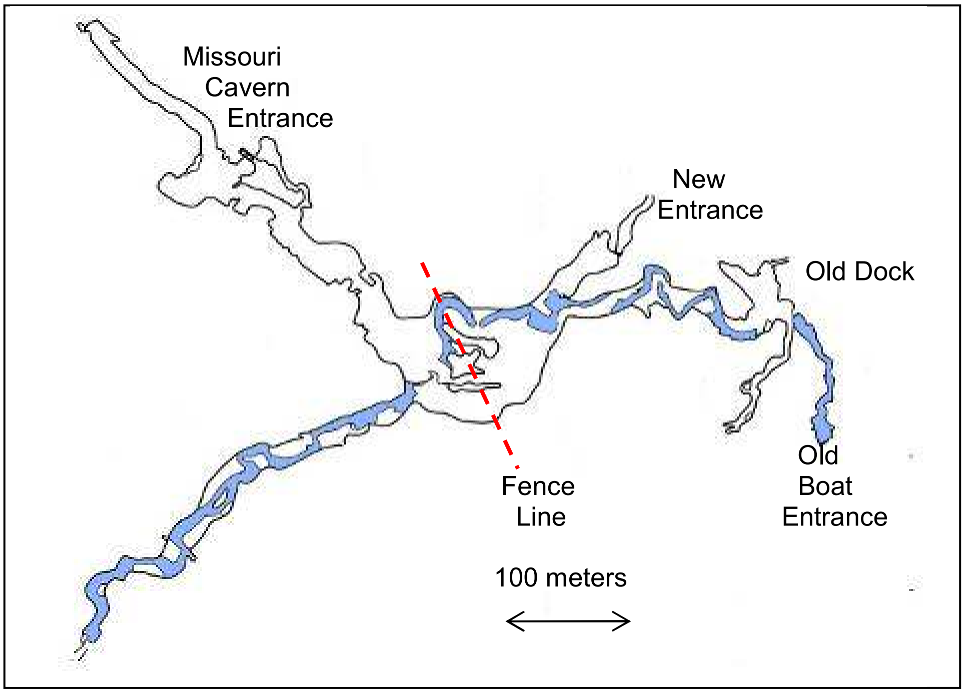
We are aware of any number of subterranean channels upon which a recreational craft might float. If such a stream is "non-navigable," however, by federal and state legal tests, it doesn't fall under the Doctrine of Public Trust with its attendant rights of public access.

For legal purposes, property ownership extends from the surface to the center of the earth. A cave and the non-navigable waters within it belong to the owner of the property above. Should a cave extend under two properties, one owner's subterranean real estate might be inaccessible because the entrance is on the neighbor's property. We've two examples from the karst states.

An "underground stream" in **Missouri** must follow a definite channel that is reasonably ascertainable, for which A Summary of Missouri Water Laws (2000), by that state's Department of Natural Resources and Attorney General, shows Onondaga Cave (Chapter 52) as an illustration.

> *The court held that the rule is that all underground waters are presumed to be percolating and therefore the burden of proof is on the party claiming that a subterranean stream exists. (See Figure 5, Onondaga Cave Map, showing an example of an underground stream.)*

A simplified rendering of the document's Onondaga map,



Note the "Fence Line."

1930 Half of the cave discovered to lie under land owned by the rival Missouri Caverns, Inc. Barbed wire strung across the chamber at the property line.

1934 Senatorial candidate Harry S. Truman toured Missouri Caverns with an entourage of Democrats on the same day that a group of Republicans toured Onondaga. The parties exchanged political disparages across the fence.

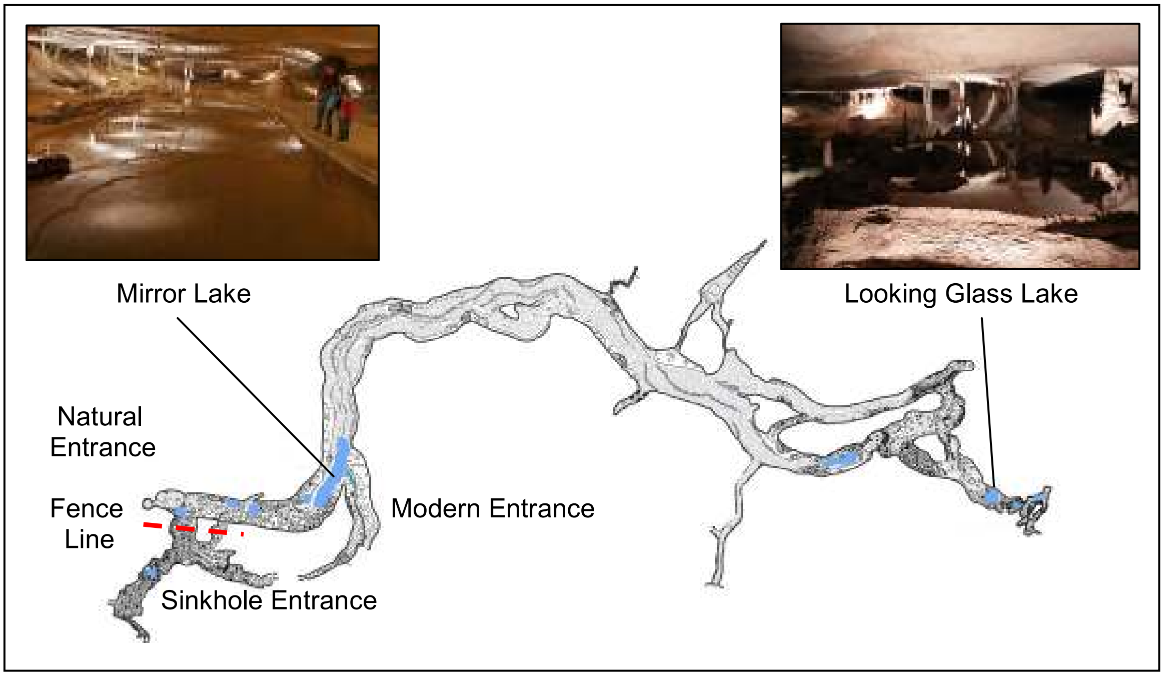
1935 Missouri Supreme Court ruled in favor of Missouri Caverns.

To be "navigable" by Missouri law, a stream must in its natural state be capable of floating vessels used in the customary pursuit of commerce, “whether foreign or inland, and whether steam or sail.” It is not sufficient that a small boat can pass through a tortuous course.

While the boating record does not appear to satisfy state criteria for navigability -- Chapter 52 shows a few tourists ferried a short distance, and certainly not by steam or sail -- the venture was indeed commercial, and thus "navigable" in the over-riding Constitutional sense. Being a recognized by the state as a "stream" and "navigable" by the federal government, even within private property, the cave river would seem to be open to the public.

There's a cavern caveat, however. As there is no public right to cross private land, a cave river navigable or otherwise, accessible only by foot, remains out of public reach.

A similar cave-splitting occurred near the turn of the century in Marengo Cave, Indiana. The natural entrance was near the property line between two brothers and the sibling without the portal excavated sinkhole to form a second entry. Each brother gave tours of the portion under his land, a wire fence separating the two.



Unlike Onondaga, however, Marengo contains nothing even arguably a navigable river, and thus the fence stood on solid ground, both literally and legally.

If a non-navigable cave river accessible from public property extends beneath private property, one cannot boat into the private portion without permission, any more than one may cross a surface boundary just because there is no fence. Entering without invitation invites prosecution for the misdemeanor of trespass.

As with the definition of “navigability,” the prohibition of trespass varies by state, but most jurisdictions hold that a person may not enter the property of another without consent if

> The property is fenced or enclosed in a manner intended to exclude intruders, or
> The property is posted in a conspicuous manner against entry.

In many cases, as we've noted however, cave entry via a navigable waterway is not trespass. In some states, the trespass prohibition does not apply to streams which while legally non-navigable, can be traveled entirely within the banks.

As the laws against trespass by land tend to be fairly rigid and consistent, it may be safer to violate the property line -- above ground or below -- by boat. Or better yet in a Constitutional sense, a hold-full of goods to sell to the cave dwellers.

The government can bar even an interstate cargo boat, however, if it has other reasons. In 2009 the Forest Service ordered an emergency closure order for all caves and mines in the National Forest Southern and Northeastern Regions

> *No one, except rescue personnel in the performance of their official duties, will be allowed within the closed areas unless authorized by the Regional Forester or Forest Supervisor. Violation of these prohibitions is punishable by a fine of not more than $5,000 for an individual or $10,000 for an organization or imprisonment for not more than six (6) months, or both, under authority of Title 16 U.S.C. 551, Title 18 U.S.C. 3559 and 3571.*

CRYSTAL CAVE
NO
TRESPASSING
AFTER
BUSINESS HOURS
POLICE
PATROL AREA

Unlike Crystal Cave of Kentucky (Chapter 52) which once featured tourist boats, "navigable" by federal standards, Crystal Cave of Pennsylvania contains only a "small pool of water about the size of a large pasta bowl," and the prohibition is legitimate.

KEEP OUT
SEWAGE
CONTAMINATED
WATER
EXPOSURE MAY
CAUSE ILLNESS

Trespass laws also protect publically-owned utilities, which in Minnesota, include gas, power, telephone, water, wastewater or other related service, owned, controlled or regulated by a local or regional government unit.

To enter an underground structure containing a utility line and not open to the public for pedestrian use, without proper consent, is a trespass. The underground structure need not be posted.

NO
TRESPASSING
This Cave is protected by
the Georgia Cave Protection Law
DO NOT ENTER
VIOLATORS WILL BE PROSECUTED TO THE FULLEST
EXTENT OF THE LAW
$250 - $1000 REWARD LEADING TO THE CONVICTION OF
ANY PERSON(S) WHO VANDALIZE THIS CAVE, THE
ACCESS CONTROL FENCE OR GATE.

Government has the right to regulate or prohibit access to public spaces for purposes of environmental protection, historical preservation, public health and well being, security, and the like.

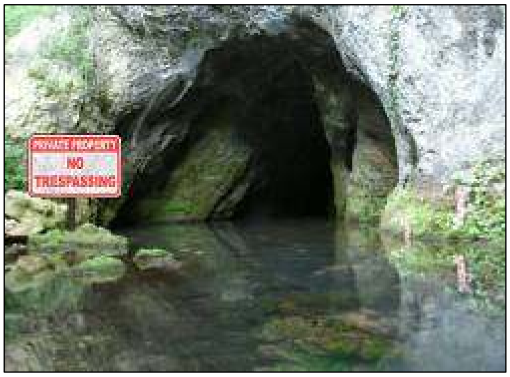
All Caves Closed
Permit Required
36CFR1.5(a)(1)

El Malpais National Monument, New Mexico closure due to outbreak of a fungal disease killing millions of bats, need to preserve delicate geological formations, cave ice, and sensitive biological communities, and need to implement a cave management program.

Conclusion

We've touched on three legal considerations potentially relevant to underground river access.

Criminal mischief harming property.
Navigability, a deep-rooted public right, strongest when related to commerce and sometimes tied to recreational use.
Trespass upon private property and public utilities.



To the right is an illustration of the court-room quandaries that can arise. Does the public have the right to enter the cave?

Arguments against.

The property is private and posted, thus protected by laws against trespass.

The stream seems too shallow for commercial transport and perhaps even for recreational boating, and thus is non-navigable.

Arguments for:

Access appears possible within the stream banks.

There may be a navigable pool within the cave to which the entrance is but a portage.

The determination likely depends on the particulars of state law. When embarking upon an underground river, an attorney may be as necessary as a rubber raft.

CHAPTER 78
BENEATH THE GREAT LAKES

For general reference, the map below shows the Great Lakes. Niagara Falls separates Lakes Erie and Ontario and the St. Lawrence River empties Lake Ontario to the northeast.

Superior
Michigan
Huron
Ontario
Erie

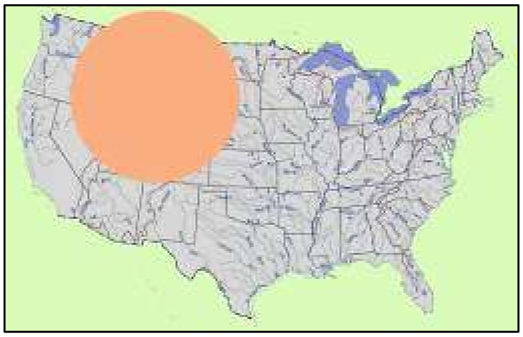
We preface our Great Lakes exploration with the "Ontario, Lake" entry from The Student's Cyclopaedia, A Ready Reference Library for School & Home (1893) by Chandler Belden Beach.

> *Ontario, Lake, one of the five great lakes of North America. It is the smallest, covering 7,240 square miles, and being 190 miles long and 55 miles wide. It forms the connection between the Niagara River and the St. Lawrence. The level of its waters varies about three and a half feet at regular periods of from four to seven years, which it is thought may be due to an underground river.*

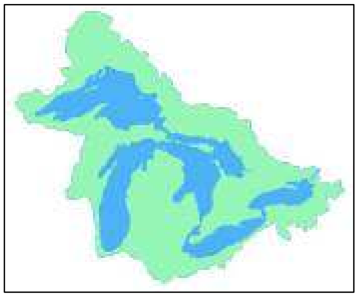
We will follow the purported underground river, lake to lake, or entirely under lakes, depending on the reference. Concerning subterranean headwaters to the west, we have "What Supplies the Great Lakes?" in the January 10, 1867, Charleston Daily News

> *Mr. George A. Shufeldt, Jr., replies that they get water from underground rivers. He calls attention to the fact that the surface tributaries of the great lakes will hardly make good the wear and tear of atmospheric absorption and evaporation. Yet the lakes are of immense size, and constantly discharge vast volumes of water through their outlets, Sault St. Marie, Mackinaw, etc., without sensible diminution. Hence, as there are no adequate sources of supply above the surface, we must look for them beneath it.*
>
> *That the crust of .the earth is full of watercourses is a familiar fact..* [Wells] *discharging great volumes of water-all tend to demonstrate the fact that the crust of the earth is penetrated in all directions and at all depths with these streams and watercourses.*
>
> *Mr. Shufeldt asks his readers to "turn to the map of North America" and note particularly the point where the thirty second degree of west longitude crosses the forty fourth parallel of north latitude. Within a radius of five hundred miles, of which this is the centre, will be found the great water-producing region of the West*
>
> *In this elevated and comparatively uneven surface of the country, nearly all of the great rivers of the West have their sources and fountain-heads. First, the Missouri, with its innumerable branches and tributaries, among which are the Yellowstone and the North Fork of the Platte, the Arkansas, the Red River, the Rio Grande, all flowing from the eastern and southern slopes of the Becky Mountains, and finding their way through thousands of miles of country to the Gulf of Mexico. On the western slope is the Rio Colorado, which empties into the Gulf of California,*

> *and which is formed by the union of the Grand and Green Rivers, the sources of which are also within the territory above mentioned.*
>
> *The .statement is true of the Columbia River, flowing through the State of Oregon in the Pacific, and or the other great streams and rivers which flow northward and westward into the Pacific and the Northern Oceans. Here, then, we have a radius from which a system of rivers proceeds in all directions but one. Oh the side of the Great Lakes there is no surface-river of any size. Mr. Shufeldt puts this fact and the equally unquestionable one of the existence of the lakes together, and constructs his theory that the lakes are fed by subterranean members of this river system, which find inlets "at different points on the bottoms of the lakes, and maintain the supply with as much certainty and regularity as if the streams were running on the surface of the ground."*



To the right is Shufeldt's circle. Most of the great rivers of the American West do indeed have "sources and fountain-heads" within this radius.



The Great Lakes watershed map lacks a major western tributary, evidence in the mind of Shufeldt that it must be subterranean from his circle.

As to whether the circle feeds a subterranean southerly drainage, we'll get there in to the chapter to follow.

Great Lake Linkages

Could there be subterranean rivers connecting the Great Lakes, one to another? Following are a few speculations.

From Old Mackinaw, or The fortress of the Lakes and its Surroundings (1860) by William P. Strickland,

> *The fathers of the missions in and around the Straits of Mackinaw gave it as their opinion, that the waters of Lake Superior entered into the Straits by a subterranean passage, and in support of it, mention the wonderful fact that the current float against the wind, and notwithstanding it drives furiously in one direction, vessels are enabled to sail in a contrary direction as rapidly as though the wind were not blowing. In addition to this, they refer to the constant boiling up of the waters. Without admitting this theory, they affirmed that it was impossible to explain two things. The first is, that without such subterranean passage, it is impossible to tell what becomes of the waters of Lake Superior. This vast lake has but one visible outlet, namely, the river of the Saut, while it receives into its bosom the waters of a large number of rivers, some twelve of which are of greater dimensions than the Saut. What then, they ask, becomes of all these waters if they do not find an issue through a subterranean river? The second reason for their belief in this theory is the impossibility to explain from whence come the waters of Lake Huron and Lake Michigan? But very few rivers flow into these lakes, and their size is such as to justify the belief that they must be supplied through the subterranean river entering into the Straits.*

From "The Great Lakes," Atlantic Monthly, February 1861,

> *Father Dalton is of opinion that the waters of Lake Superior enter into the Straits by a subterranean passage. This theory, he says, is necessary to explain two things, namely:*
>
> *1st. Without such a passage, it is impossible to say what becomes of the waters of Lake*

> *Superior. The vast lake has but one visible outlet, namely the River of St. Mary; while it receives the waters of a large number of rivers, some which are of greater dimensions than the St. Mary. What, then, becomes of the surplus water?*
>
> *2d. The difficulty of explaining whence comes the waters of Huron and Michigan. Very few rivers flow into these lakes, and their volume of water is such as to fortify the belief that it must be supplied through the subterranean river entering the Straits.*

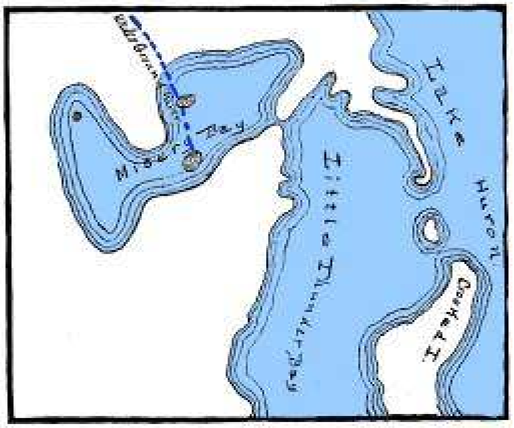
I.A. Lapham, "The Supposed Subterranean Sources of the Waters of the Great Lakes," Chicago Academy of Sciences, April 9, 1867, raised the same perplexity.

> *It is quite certain that the whole quantity of rain water falling into the Great Lakes, and the country drained into them, will be found to be two or three times as much as in discharged at Niagara, and hence the wonder is what becomes of the excess, rather than to account for deficient supply.*

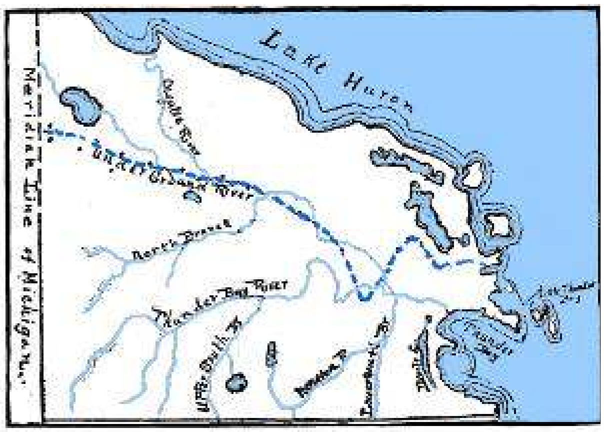
Thunder Bay, Michigan is separated from Lake Huron on the northeast by North Point and across the Point is Little Thunder Bay, well guarded by thickly wooded Islands. From this bay, says Mr. Franklin S. Dewey in Outing, October 1913,

> *I entered a narrow, shallow passageway, and there was revealed a secluded little inland lake surrounded by rocky bluffs. The little skiff swam through the weedy shallows and out over a patch of blue, almost black water.*
>
> *But it was almost noon, and soon I had a brisk fire blazing on the sand, and a bass sputtering over it. Then I saw that the water was slipping up to the fire. It surrounded it, enveloped it, put it out. I built a new fire out of reach of the rising "tide," but all the afternoon I watched a curious phenomenon. Twenty minutes' ebb and twenty minutes' flood -- It never failed. I picked up a stone, attached it to my trolling line and sounded the depth of the singular pond. It was just a hundred feet deep.*
>
> *I determined to sift this natural curiosity to the bottom, and I began to ply everybody who knew the woods with questions. At last I was directed to the Narrows, some six miles north. There was nothing strange there. Just a long, slim lake. Long Lake poured a little river into it, and a creek crept out into Caroline Bay. There came a dry spell and I visited the Narrows a second time. The lake had disappeared. In its place was a long ravine and at the bottom flowed the little river from Long Lake.*
>
> *Then I heard; of "The Devil's Soup Bowl," some three or four miles to the northwest. Here I found a dry hole a hundred feet deep. Farther on I found more pits, some filled with water and others dry. Following the line of wells I came to the largest, some twenty miles from Alpena. It was full of water to the brim, and it took three hundred feet of line to fathom it. The line of wells led steadily northward into Presque Isle. Suddenly, between the trees, I found a long, deep defile, with a foaming river rushing down it. It was a mile in length and terminated a pool or pit surrounded by high walls. In the great throat of this pit 150 feet deep, the river was swallowed up and disappeared. Far to the north I found scores of other pits with their great mouths open to the sky; some of them swallowed surface s reams of lesser magnitude. Some of them became at certain seasons a veritable porridge of fish. Later the same wells ran dry*
>
> *I followed the general direction of these pits for thirty miles farther; the last of the series close to the Michigan meridian. It cannot he doubted that they clearly mark the sixty-mile course of a subterranean river which issues in the tidal lake off Little Thunder Bay, and mingles with Lake Huron.*
>
> *The entire course of the river is in Hamilton limestone. Ancient earthquakes have shattered the rock and the surface streams, creeping into the clefts, have gnawed the walls away.*

Dewey's maps are shown below.



Where the First Hint Came of the Subterranean River



The Course of the River from Source to Mouth

"On the Subterranean Sources of the Waters of the Great Lakes," American Journal of Science and Arts, March 1867, by George A Shufeldt argues for subterranean watercourses much longer.

> *If we take down the map of North America, and follow around the borders of our chain of Great Lakes, we find that the tributaries for supplying the mighty torrent of water which pours in immense volumes over the Falls at Niagara, and thence through the St. Lawrence to the sea, are few in number and insignificant in effect... Now the question arises, whence comes this great volume and mass of running water?*
>
> *Geologists are tolerably familiar with the subject of underground streams and water courses. They know that the crust of the earth is full of these streams, and although from the fact that they are generally concealed from sight, there must be considerable speculation concerning them, yet there are cases, such as in the Mammoth Cave, Kentucky, the Adelsberg mountains in Switzerland, and numerous artesian wells scattered all over the world, the lost rivers on our western prairies, &c., from which a positive knowledge may be derived concerning the nature and history of these rock bound rivers.*
>
> *Adopting this as a conceded fact, let us once more turn to the map of North America and note particularly the point where the thirty-second degree of west longitude crosses the forty-fourth parallel of north latitude. Within a radius of five hundred miles, of which this is the center, will be found the great water producing region of the West.*
>
> *It is a well-known fact to travelers on our western plains that large streams, often rivers in size, suddenly disappear, falling away into great fissures and chasms, sometimes reappearing, but more frequently lost forever; where and in what manner does this water find an outlet? What becomes of the mass of water which falls upon the earth and is absorbed by the soil and the rocks below the beds of rivers and streams?... If the Great Lakes are not supplied by means which are upon the surface and apparent to the eye, it follows as a natural consequence that their sources of supply must be underneath the ground... This water probably finds inlets at different points on the bottoms of the lakes, and maintains the supply with as much certainty and regularity as if the streams were running on the surface of the ground.*
>
> *It is also probable that the great under-ground stream, penetrated by these wells, once discharged its waters into the bottom of Lake Michigan; but this outlet was closed by the upheaval of the earth's crust, which is visible at the point of the location of these wells, and at the present time there is no outlet except the artificial one made by the drill... As soon as an opening or outlet was made, and a quantity of water was discharged, this mineral matter decreased in proportion, and the probability now is that the water will become softer and purer as the amount discharged becomes greater, and that eventually, and probably at no distant*

> *day, the water will come from its fountain-head, simply filtered and purified by its passage through the sandstone and gravel beds.*

In The Great Lakes Triangle (1977), Jay Gourley claims that the Great Lakes account for more unexplained disappearances per unit area than the Bermuda Triangle. Were those lost, lost to a maelstrom?

Fish Passage

Let us begin with a news item, "The Mystery of the American Lakes."

> *Lake Erie is only 60 or 70 feet deep, but the bottom of Lake Ontario, which is 452 feet deep, is 230 feet below the tide-level of the ocean, or as low as most parts of the Gulf of St. Lawrence; and the bottoms of Lakes Huron, Michigan, and Superior, although their surface is so much higher, are all, from their vast depth, on a level with the bottom of Lake Ontario. Now, as the discharge through the river Detroit, after allowing for the full probable portion carried off by evaporation, does not appear by any means equal to the quantity of water which the three upper great lakes receive, it has been conjectured that a subterranean river may run from Lake Superior to Huron, and from Huron to Lake Ontario. This conjecture is by no means improbable, and accounts for the singular fact, that salmon and herring are caught in all the lakes communicating with the St. Lawrence, but in no others. As the Falls of Niagara must have always existed, it would puzzle the naturalists to say how these fish got into the upper lakes without some such subterranean river ; moreover, any periodical obstruction of this river would furnish a not improbable solution of the mysterious flux and reflux of the lakes.*

Perusal of digitally-archived period periodicals -- but a few percent of the era's prodigeous output of newsprint -- yields the verbatim text in the following publications.

The Dublin University Magazine	August 1851
The Eclectic Magazine of Foreign Literature, Science and Art	October 24, 1851
Montreal Pilot	December 27, 1851
Detroit Daily Free Press	March 27, 1852
New Zealand Spectator and Cook's Strait Guardian	June 2, 1852
The Adams Centinel (Gettysburg)	June 7, 1852
The Plough, the Loom, and the Anvil	Vol. 4, 1852
Baltimore Sun	November 10, 1858
Daily Morning Press (Adrian, Michigan)	September 25, 1874
Orangeburg (South Carolina) Times	November 26, 1874
Sydney Morning Herald	January 11, 1875
California Farmer and Journal of Useful Sciences	November 4, 1875
Grey River Argus (New Zealand)	January 26, 1876
Evening Auburnian (Auburn, New York)	January 20, 1879
Oswego Morning Herald	January 28, 1879
Daily Free Press (Easton, Pennsylvania)	February 6, 1879
Sacramento Record Union	October 4, 1879
The Princeton (Minnesota) Union	November 5, 1879
St. Paul Daily Globe	May 9, 1880
Geneva (New York) Gazette	March 17, 1882

"The Mystery of the American Lakes" persisted over three decades, and we're not including repeats in which the editor took the time to re-write a portion of the content.

We've quoted a good number of underground river news articles in our journey so far, and there are more yet to come. What might seem to be a minor story in an obscure newspaper was probably mirrored in hundreds of sister publications.

"A Summer on the Great Lakes," Bay State Monthly, October 1884, also wondered about the fish.

> *Lake Erie is about two hundred and forty miles in length and has a mean breadth of forty miles. Its surface is three hundred and thirty feet above Lake Ontario, and five hundred and sixty-five*

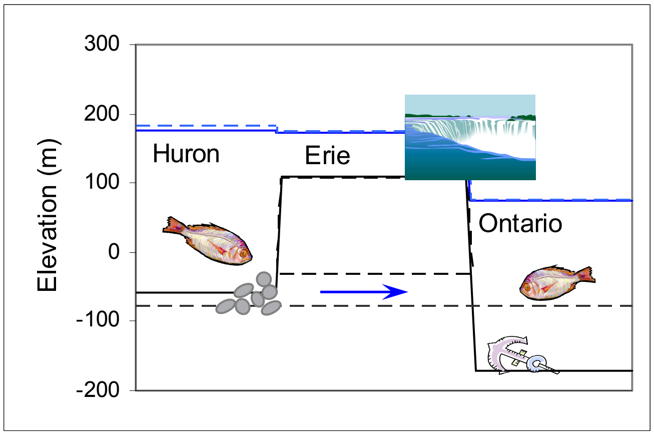
> *above the level of the sea. It receives the water of the upper lake by means of the Detroit River, and discharges them again by the Niagara into Lake Ontario. Lake Ede has a shallow depth, but Ontario, which is five hundred and two feet deep, is two hundred and thirty feet below the tide level of the ocean, or as low as most parts of the Gulf of St. Lawrence, and the bottom of Lake Huron, Michigan, and Superior, although their surface is much higher, are all, from their vast depths, on a level with the bottom of Ontario. Now, as the discharge through Detroit Rivet, after allowing all the probable portion carried off by evaporation, does not appear by any means equal to the quantity of water which the other three lakes receive, it has been conjectured that a subterranean river may run from Lake Ontario. The conjecture, not improbable, and accounts for the singular fact that salmon and herring are caught in all the lakes communicating with the St. Lawrence, but no others. As the Falls of Niagara must always have existed, it would puzzle the naturalists to say how the fish got into the upper lakes unless there is a subterranean river; moreover, any periodical obstruction of the river would furnish a not improbable solution of the mysterious flux and influx of the lake.*

And for a few more numbers, the Farmer's Advocate of June 12, 1884, quotes a "resident of Ithaca, who has a taste for geological research,"

> *I believe there is a subterranean river running from Lake Superior through Lake Huron and Michigan, under Lake Erie, and emptying into Lake Ontario. There is no other way in which to explain certain mysteries connected with our great lakes. The surface of Lake Superior is about 650 feet above tide, while its bed is about 260 feet below tide level. Lake Huron's surface is 50 feet below that of Superior's... The Erie's surface is nearly as high as Lake Michigan's, being 565 feet above tide, but its bed is also above tide, being 350 feet higher than the ocean level, consequently its bed is 250 feet higher than those of the lakes above it. Lake Ontario's surface is the lowest of all the great lakes, being less than 500 feet above tide, but its bed is 260 feet below the ocean, or about the same level as Michigan, Huron, and Superior. So there is a continuous fall from Lake Superior to Ontario, and all the outlet that the upper lakes have is known as the comparatively insignificant Detroit River. That stream never can care for all of that great pressure and volume from above, and the theory of an underground river such as I mentioned, seems to be most reasonable. All the St. Lawrence fishes are taken in every one of the lakes but Lake Erie. Why? Because they follow the course of the subterranean stream, passing 300 feet beneath the bottom or Lake Erie, and enter the waters of the upper lakes. The great lakes above Lake Erie have occasional flux and reflux of their waters, corresponding with ocean tides save in regularity.*
>
> *The subterranean river, according to my theory, becomes occasionally obstructed by great obstacles that are constantly moving down lake bottoms. Then the channels of outlet are insufficient to carry off the great volume of water, and they dammed back and the lakes rise. Finally these obstructions are swept away by the irresistible pressures, the river flows naturally once more, and the dammed waters subside. That is the whole mystery of the rise and fall of the tides in the great lakes.*

In short, where does the upper lakes' excess water go and how did the fish pass Niagara Falls?

The diagram below illustrates the elevations of Huron, Erie and Ontario. The solid line shows the true values and the dashed line, those given in the Farmer's Advocate. Note that the underground river outlets in the pool below Niagara Falls. The underground river below is shown temporarily blocked by the "great obstacles that are constantly moving down lake bottoms."



If the Farmers Almanac seems too geologic, the Farmer's Cabinet of January 9, 1868, covered the human aspect.

> *It was discovered several years ago by a man who was returning from a day's chopping in the woods. In walking over a slightly sunken place he noticed a hollow should, and turning struck the ground with his ax. The ax broke through and disappeared, and never has been heard from since... A lead and line let down to the depth of seventy feet found no bottom... It is certainly quite a remarkable stream.*

For non-farmers, the 1889 Encyclopedia Britannica's entry for Lake Ontario surmises that,

> *As the Falls of Niagara block the way, would seem that the fish reached the upper lake by way of an underground river. The theory of an underground river has also been adopted by several scientists who have been watching the variations in the levels of the great lakes.*

If nothing else, the source of salmon in the upper Great Lakes provided fodder for newspaper wars.

The April 24, 1852, Scientific American reported an assertion made by the Welland Advocate,

> *Now, as the discharge through the River Detroit, after allowing for the full probable portion carried off by evaporation, does not appear by any means equal to the quantity of water which the three upper great lakes receive., it has been conjectured that a subterranean river may run from Lake Superior to Huron, and from Huron to Lake Ontario. This conjecture is by no means improbably, and accounts for the singular fact that salmon and herring are caught in all the lakes communicating with the St. Lawrence, but in no others.*

To which Scientific American subscriber J.E. Holmes responded in the May 8, 1852, issue.

> *As Lake Huron is at least 280 feet above Lake Ontario, no large body of water could pass from one to the other without occasioning a vast whirlpool at one end of the passage, and an immense boiling jet at the other.*

The Scientific American of April 16, 1859, quoted the Golden Era, "a very sprightly paper published in San Francisco," which in turn was quoting an Ohio newspaper.

> *In answer to the rather absurd assumption of the editor of the Scientific American that the salmon and herring found in the lakes above Niagara must have passed into these waters originally through some subterranean stream connecting with the ocean, a writer in the Defiance (Ohio) Democrat says it is much more reasonable to believe the fish entered the Upper Lakes by way of the Fox River, which connects the Mississippi with Green Bay and Lake Michigan, and through a passage connecting Georgian Bay and the Ottawa.. If this be rejected, we are driven to the less rational presumption that fresh water possesses the elements of Animal creation.*

To this, Scientific American responded,

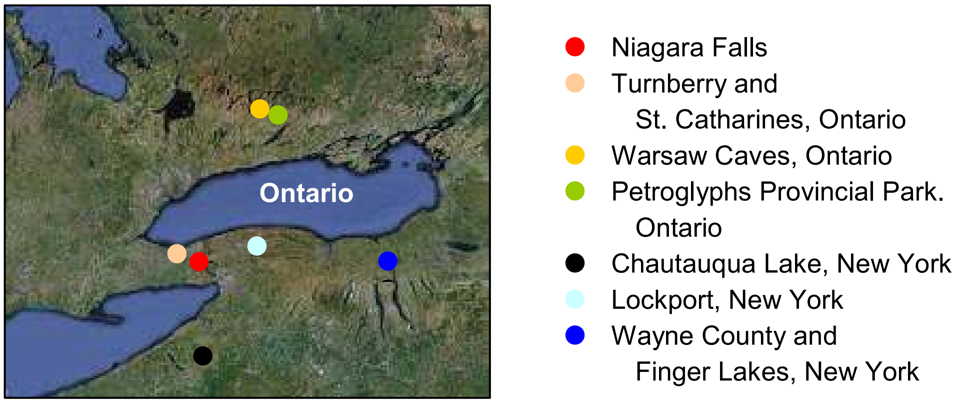
> *The writer of the Defiance Democrat seems to be unacquainted with the nature of salmon; they are a northern cold-water fish, and are therefore not very likely to make a journey to the Lakes through the warm Gulf of Mexico and thence up the Mississippi. The idea is absurd.*

A lively editorial debate sells papers, but it may leave a perplexed readership.

Perplexed for decades to come, as a matter of fact, as evidenced by February 26, 1914, Urbana Daily Courier,

> *London, Ont. There is a condition approaching panic in Turnberry, hear here, as a result of a series of occurrences which indicate that the land within its borders is sinking into an underground river. Farmers in the vicinity fear that their farms and stock will be lost in the quicksands which have developed, and the government has been asked to make an investigation.*
>
> *The first indication of the menace came when a section of road 200 feet long sank 50 feet and was found to be a spongy mass at its base. Within a few days a plot many rods long sank just outside of Belgrave and a pool of water formed in the bottom of the hole it made.*
>
> *A geologist who stopped in Turnberry said that scientists believe a large subterranean river connected Lake Huron and Lake Erie, as small fish peculiar to Lake Ontario had been found in Lake Huron within the last few months.*

It would be well to clarify some geography, locations in the vicinity of Niagara Falls.


Ontario
● Niagara Falls
● Turnberry and St. Catharines, Ontario
● Warsaw Caves, Ontario
● Petroglyphs Provincial Park. Ontario
● Chautauqua Lake, New York
● Lockport, New York
● Wayne County and Finger Lakes, New York

As St. Catharines lies on the isthmus between Lakes Erie and Ontario, readers of the February 8, 1906, Niagara Falls Gazette would have had reasons for concern regarding "Underground Rover Found."

> *The river was struck on a farm at Nelles Corners, by some men who were drilling for natural gas. The drill had got down to 500 feet when it suddenly took a drop of 39 feet. Upon being taken out, it was marked by 39 feet of water. The men were able to hear a rumble on the water as it rushed along under the earth. Some of the water was pumped out, and some small fishes came to the surface. The water had the taste of lake water. The men could not tell which way the river was running. The general impression about the neighborhood is that the river is an underground channel connecting two of the great lakes. All of the bored wells around Nelles Corners have given out, probably being drained by the river under the earth.*

That the men were uncertain regarding the direction of flow seems odd, given the Niagara Falls elevation difference between Lakes Erie and Ontario, but pending the river's verification, its direction's of secondary concern.

"Florida's Underground Streams," Los Angeles Herald, December 15, 1907, describes in wonder the sinkholes and subterranean waterways of Florida, Chapter 40. The article then continues,

> *It is a well-established fact that there is a river flowing under the bed of Lake Erie, connecting the waters of Lake Ontario with those of the upper lakes. The peculiarity of Florida's system of natural underground drainage is its proximity to the surface. Understanding this subject, many of the State's peculiar topographical features are easily explained.*

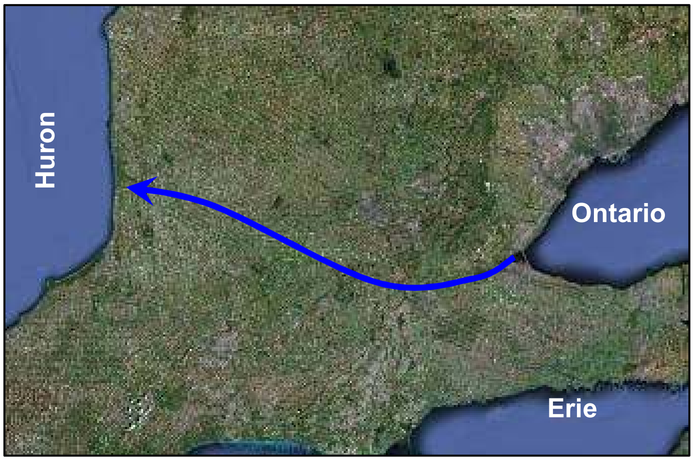
The river beneath Lake Erie is a "well-established fact," or perhaps more accurately, as we have seen, a well repeated fact. And then there's Professor Denton's plan to drain the lake entirely in, but that must wail until Chapter 83.

And much more recently, the Kitchener, Ontario Record of October 26, 2007 featured "The Quest for an Ancient River."

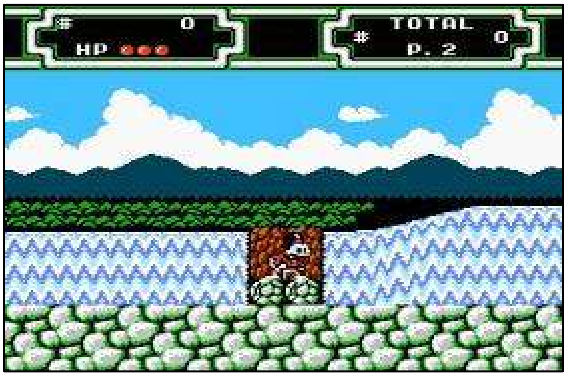
> *Geologists think there's an ancient riverbed under southwestern Ontario, which, amid layers of sand and gravel, might hold a huge supply of drinking water for an area that has known drought as recently as this summer.*
>
> *The ancient underground riverbed is known as the Dundas Buried Bedrock Valley.*
>
> *"This is very much a practical program," said Desmond Rainsford, a geophysicist at the Ontario Geological Survey in Sudbury.*
>
> *He's overseeing a gravity survey that researchers hope will reveal a riverbed carved in bedrock by a monster river that flowed from Lake Ontario towards Lake Huron, more than 10,000 -- and perhaps hundreds of thousands of -- years ago. Slight variations in gravity will show researchers how far the bedrock lies beneath the surface.*
>
> *Geologists suspect the riverbed is now filled with sand and gravel trapping and holding huge amounts of pristine water.*

The map shows the route. While the direction seems wrong, it agrees with geological evidence that the upper Great Lakes at one time drained southward, the topic of the chapter to follow, "Veins of the Heartland."

We include it in this chapter, however, since we're in the area.



In the video games discussion of Chapter 27, we didn't mention Duck Tales in which Uncle Scrooge and his nephews ascend Niagara Falls. The screenshot makes clear that the route's subterranean.



A different sort of river-under-Niagara story stemmed from the fall's erosion. From "Niagara Falls," Christian Advocate, January 30, 1868,

> *If the limestone ledge over which the river now falls is, as supposed, in the course of being an undermined by a subterranean stream, breaking through as far back as nearly half a mile, of course the consequence, inevitable and liable to ensue at any moment, must be an immense breaking away of the face of the cataract, changing its whole form and appearance, perhaps converting the perpendicular fall into a shooting rapid, down a steep decline.*

We saw in Chapter 62 that the Mississippi's St. Anthony Falls did indeed degenerate in much the above manner. While Niagara is abrading its way upstream at approximately 0.3 meters/year, there's little expectation of a catastrophic conclusion.

As for from-whence-came-the fish? quandary, the answer predates even the glacial periods. No underground river would have been needed to populate the fishery, as the region was once covered by a shallow tropical sea.

> *From about 16 million to 2 million years ago, the giant shark megalodon dominated the seas as the largest marine predator to ever live. Despite being extinct for millennia, the megalodon caused a stir in southeast Michigan last August when 15-year-old Port Huron resident David Wentz discovered a fossilized tooth in the St. Clair River*. -- Michigan Science, July 8, 2008

And Onward Toward the Sea

If an under-falls passageway made sense, why not run the conduit yet onward to the east? We only have to look to the Province of Ontario for evidence.

Warsaw Caves has hundreds of "kettles" -- bowl-shaped depressions in the limestone ranging from 5 centimeters to more than 2 meters in diameter and 4 meters in depth. Kettles develop in the bed of a fast flowing river where an eddy causes bed material to swirl in the same place over a long period, and thus are evidence of a previous large channel.

The Warsaw area is characterized by limestone bedrock shaped by the glaciations which 12,000 years ago created the present-day Great Lakes. The rebound of the bedrock means there is no longer water in the upper caves, though there are still flowing channels beneath.

Petroglyphs Provincial Park has a large collection of ancient petroglyphs thought my most to have been created by the Algonquian people around 900-1400.

The site is that it is also believed to be a portal to the spirit world. There are cracks in the rocks and an underground river underneath such that when the river is flowing, there are sounds resembling human conversations.

Or maybe the subterranean stream lies under Yankee soil. As evidence, we have the ambitious Thomas Milner's The Gallery of Nature, a Pictorial and Descriptive Tour Through Creation, Illustration of the Wonders of Astronomy, Physical Geography, and Geology (1882) account of Lockport, New York, just a few kilometers below the falls.

> *There is in Lockport, New York, an artesian well four hundred feet in depth, from the bottom of which rises a vein of salt water, holding in combination a large percentage of diliquescing chlorides, which, mingling with waters of other veins, produce instantaneous crystallizations of beautiful selenite in flattened eight-sided prisms of about an inch in length, an eighth of an inch in width, and a sixteenth of an inch in thickness. The laminae of these are so perfect that a single crystal may be divided, by means of heat, into two dozen distinct sheets. This well is accustomed to spout salt water for but a few moments at a time, and then, subsiding, remains quiet for the space of an hour, at the conclusion of which it again begins to puff and roar, and shoot forth its saline jets, when the workmen were sinking this well, the, auger, upon attaining a depth of two hundred and thirty-five feet, fell suddenly about fourteen feet, find reached the bottom of a subterranean river, flowing with so strong a current as to produce a perceptible motion in the upper part of the stem of the anger.*

"Extraordinary Well," Christian Secretary, November 24, 1843, has this to report.

> *I have received from a gentleman residing in Wayne County, a bottle of water of great specific gravity... It is from a depth of 360 feet below the surface, and is from a subterranean river, the volume of which is composed of that fluid. When the augur reached the surface of this river, it fell 14 feet; the water at once rose to the surface, and in a short time inundated the building in which the shaft was sunk. It was accompanied by a large volume of carburetted hydrogen gas.*
>
> *The current of the subterranean stream is so strong as to cause the stem of the augur to vibrate when held with the hands, and of force sufficient to denote the course of the flow of water. The power of the current is increased by the specific gravity of the fluid.*

Chautauqua Lake below Lake Erie is another site where underground streamflow has been supposed. From "Why Do Springs and Wells Overflow?" Popular Science Monthly, November 1879,

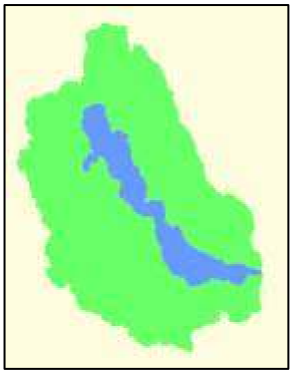
> *Chautauqua Lake rests like a jewel in the crown of a high mountain-ridge... The lake has the appearance of being lifted up above its shores; you seem to be looking up to a "hanging lake," and you wonder the whole concern does not fall over into some of the valleys close around it. It is a wonder to the unpracticed observer where the water supply of Chautauqua Lake comes from. The lake nearly fills its own valley.*
>
> *There is not a live stream emptying into it, save one, and that would run through a six-inch pipe. Of course, it is supported like a weary sleeper by the springs in its bed. These must be innumerable to maintain a body of water 20 miles long and two miles wide. Where the water is shallow you can plainly see these springs bubbling up from the bottom of the lake. Their warmth cuts the ice out in large spots in winter at points where they are most numerous. You see floating in the lake tufts of water-grass, which have been uprooted from the bottom by these under-currents.*

> *This lake is on the highest land in the State, west of the Catskill Mountains, and yet it is but a vast overflowing spring from which issues a large mill-stream. To account for this large flow from the top of this elevated region by supposing it to fall from some other higher elevation is absurd, since there is no such higher ground from which it could flow without being exhausted.*

From "A Village Sea Serpent," Will Carleton's Magazine, Everywhere, June 1907, by Jennie A.. Long,

> *Rev. John W. Sanborn, the distinguished Indianologist, who lived there at one time, and knows all the circumstances, says that in one part of the lake was a place that had never been sounded -- no matter how deeply the plumb-line had gone. "It may be," he asserts, and many agree with him, "that there is an underground river connecting it with Lake Erie, or Ontario -- not so many miles distant -- or even with the ocean. We cannot tell what feeds Lake Chautauqua with water; there is no inlet at the surface, and it is hundreds of feet higher than any other water within hundreds of miles: there must be subterranean streams to feed the giant springs. If there are underground passages leading into this little lake of the sea-serpent, there was no doubt room for him to make his way through."*

Local geography, however, doesn't need such sea-serpent-sized conduits. Chautauqua Lake and its watershed are mapped to the right, the water surface approximately one-eighth of the total. The area's 115-centimeter annual precipitation is easily sufficient to maintain the lake.



"Rise and Fall of Lake Ontario," The Merchants' Magazine and Commercial Review, June 1, 1853, provides another hint of cavernous channels in the Empire State.

> *The Cratean Lakes of Manlius, which are tributary to Lake Ontario, are, no doubt, of volcanic origin.*

As a modern atlas doesn't show lakes of this name, we show the finger-lakes regional geography to the right. What's important is that by no means is the landscape of volcanic origin; it's glaciated limestone

The Merchant's account that follows makes more sense in that light.

> *A farmer who resides near the "Lower Lake" informed me that one afternoon, while plowing near the shore of the Lake, he heard a sudden rush of water behind him, on turning around, on seeing the Lake rising over the land he fled, with his team, but the water soon returned to its basin. The "Lower Lake" has low banks, which appear to have sunk down; it receives the surplus water of the "Upper Lake" through a chasm in the bank of that Lake, and discharges a*

> *small stream that runs under the Erie Canal... There are deep fissures and chasms around the border of the "Upper Lake," and also deep sinks, in which large trees are swallowed up. Such is the condition of some of the districts that border Lake Ontario, and therefore belong to the history of the Lake, as connected with its mysterious changes of surface.*

The Tourist's Guide Through the Empire State, Embracing all Cities, Towns and Watering Places by the Hudson River and New York Central Route (1871), edited by S.S. Colt, then moves us again eastward.

> *At Clarksville, twelve miles from Albany, and eight or tell miles southeast from the Indian Ladder, are more caves. Two of these are well known; the entrance of one is in the back-yard of one of village houses. The subterranean river is the house well; a trail of steps leads down into a crevice in the rock. They have no other water. For drinking it is unsurpassed, but it issues from lime rock. This same river bursts forth near by in the bed of the Oniskethau, and aids that stream to run a saw and paper mill. Chaff thrown upon the river in the cave is soon found floating on the mill-pond. The stream empties into the Hudson at Coeyman's. It was once remarked that an amphibious animal might make its way through the caverns from Hudson River to Niagara Falls without once coming forth to daylight!*

From the Elmira Star Gazette, March 14, 1896, "Underground River, An Authority Says the Notion is Erroneous,"

> *Even since the subject of a new water supply for Elmira* [about midway between Lockport and Clarksville] *has been discussed there have been frequent references to an underground river, which according to popular theory would furnish an inexhaustible supply of water if it could be reached by wells. Belief in this underground river and in the purity of its water has been strong and widespread, and the imagination and ready tongues have embellished the accepted fact with all manner of extravagant details concerning its source, course, outlet, etc.*
>
> *A scientist of considerable note, who probably knows more about the geological formations of Chemung valley than does any other man in Chemung valley, said yesterday that this popular notion of an underground river is erroneous. "There is," he said, "below the gravel and above the living rock a sheet of water moving very slowly toward Newtown creek..." This sheet of water, technically known as "groundwater," is the water that has filtered down through the sand and gravel and is practically pure.*

The Albany Evening Journal, April 28, 1923, had this follow-up, "Underground River Only Figurative," however.

> *The term "underground river" applied to any source of water supply in the vicinity of Schenectady and Rotterdam* [30 kilometers north of Clarksville] *is purely figurative, according to Dr. John M. Clarke, state geologist... "We cannot have an underground river unless there is a limestone foundation, and this does mot exist around Schenectady."*

So perhaps there's no subterranean Great Lakes River, at least under New York, but it's not for lack of speculation.

CHAPTER 79

VEINS OF THE HEARTLAND

In the chapter just completed, Beneath the Great Lakes, we followed an underground river flowing eastward, as do the water bodies above. But could the runoff from the upper watersheds flow to the Gulf of Mexico as veins beneath the American heartland?

Such a great southward-flowing underground river has long been pondered, sometimes literarily and sometimes geographically. In this chapter we'll follow the path of the Mississippi, or at least paths in such a direction.

The table below lists some of our encounters to this point with underground rivers flowing towards the Gulf of Mexico.

Chapter	
12 Underground Rivers in English Fiction	T.S. Elliot's “At what point in its course does the Mississippi become what the Mississippi means?” Mark Twain
13 Boys Club Serials 14 Boys Club Singles	Old Olaf's report of interior rivers "larger than our Mississippi and Amazon Rivers combined, in point of volume of water carried." O Brother, Where Art Thou?
24 Underground Rivers in the Fine Arts	George Catlin's theory of a subterranean river carrying the drainage of the Rockies to the Gulf.
26 Hydrogeology	Subterranean channels of petroleum The Ogallala aquifer
41 More Hydropower from the Deep	St. Anthony Falls, Minneapolis

Author Grace Kings' Little Convent Girl (1893) entwines issues of race, gender and identity. After spending most of her life in a convent, a young girl travels by riverboat to New Orleans to join her mother who turns out to be "colored." The riverboat pilot is the tale's philosopher.

> *It was his opinion that there was as great a river as the Mississippi flowing directly under it -- an underself of a river, as much a counterpart of the other as the second story of a house as of the first; in fact, he said they were navigating through the upper story. Whirlpools were holes in the floor of the upper river, so to speak, eddies with rifts and cracks. And deep under the earth, hurrying toward the subterranean stream, were other streams, small and great, but all deep, hurrying to and from that great mother-stream underneath, just as the small and great overground streams hurry to and from the mother Mississippi.*

Little Convent Girl's tragic conclusion:

> *No one was looking, no one saw more than a flutter of white petticoats, a show of white stockings, as the little convent girl went under the water. The roustabout dived, as the roustabouts always do, after the drowning, even at the risk of their good-for-nothing lives. The mate himself jumped overboard; but she had gone down in a whirlpool. Perhaps, as the pilot had told her whirlpools always did, it may have carried her through to the underground river, to that vast, hidden, dark Mississippi that flows beneath the one we see; for her body was never seen again.*

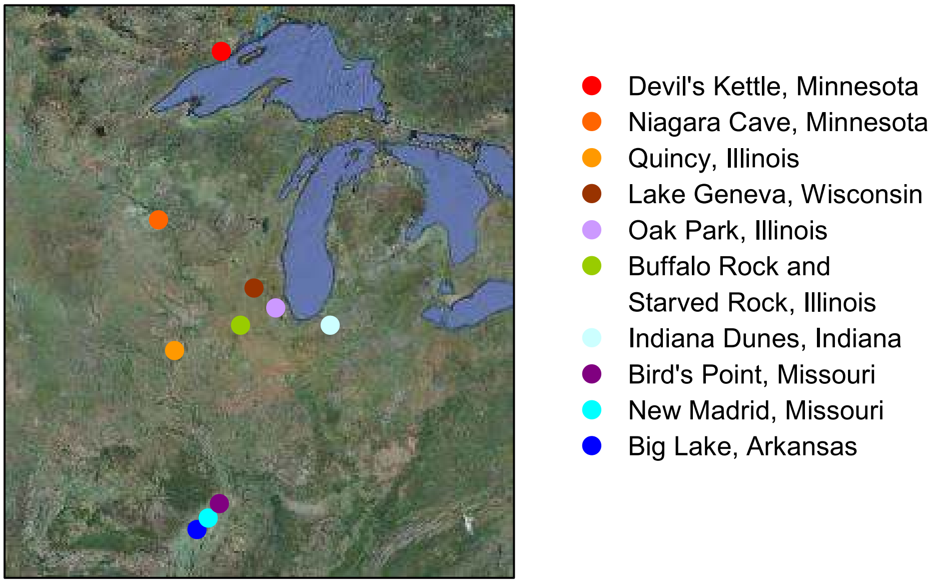
The "dark Mississippi that flows beneath the one we see" images the American experience.

From very much a different library shelf, George P. Marsh provides this account of Floridian hydrogeology in The Earth as Modified by Human Action (1874).

> *In January 1857, a submarine fresh-water river burst from the bottom of the sea not far from the southern extremity of the peninsula, and for a whole month discharged a current not inferior in volume to the River Mississippi, or eleven times the mean delivery of the Po, and more than six times that of the Nile. We can explain this phenomenon only by supposing that the bed of the sea was suddenly burst up by the hydrostatic upward pressure of the water in a deep reservoir communicating with some great subterranean river or receptacle in the mountains of Georgia or of Cuba, or perhaps even in the valley of the Mississippi.*

This "deep reservoir communicating with some great subterranean river or receptacle... perhaps even in the valley of the Mississippi" isn't allegorical; it's what the author takes to be fact, a subterranean outlet of Mississippian magnitude.

But let us become more geographic and locate such a river. For quick reference, here are some of the locations where we'll peer into the ground.


● Devil's Kettle, Minnesota
● Niagara Cave, Minnesota
● Quincy, Illinois
● Lake Geneva, Wisconsin
● Oak Park, Illinois
● Buffalo Rock and Starved Rock, Illinois
● Indiana Dunes, Indiana
● Bird's Point, Missouri
● New Madrid, Missouri
● Big Lake, Arkansas

We'll begin at the top of the map, Devil's Kettle, Minnesota. The Great Lakes have long been associated with mysterious disappearances.

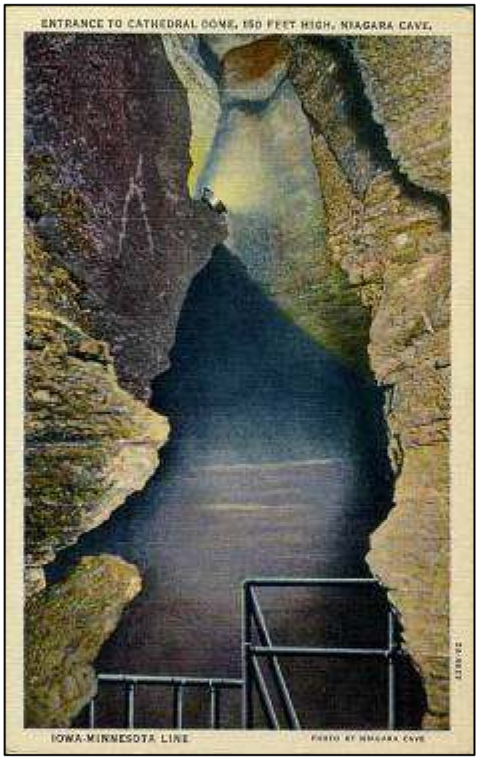
> *Devil's Kettle is a puzzling geological phenomenon located on the North Shore of Lake Superior. Where does the water go? No one seems to know.*

But perhaps we do know. South.

Niagara Cave in Minnesota, the next down on the map, features an 18-meter waterfall and a chapel in which there have been over 400 weddings.

Niagara
$10.50

The cave is said to be named after Niagara Falls at Lake Ontario -- a less flamboyant Niagara Falls for Norwegian settler weddings, perhaps, but could it not also be another Niagara Falls, this one pointed south?



We extend our line the dot for Quincy, Illinois. From the Quincy Daily Journal, February 13, 1895,

> *Papers published in neighboring towns are vividly describing an underground lake just discovered near Quincy... The discussion of artesian wells as a means of supplying the city with water, led some of the older citizens to put on their thinking caps, and then came stories of underground lakes and rivers which are large enough (the stories are at least) to supply the city's every need with water pure as crystal. One citizen remembers that about fifty years ago...*

The story then recounts a tale of a well shaft revealing a "great body of water, above which the rocks form an arch."

> *Another story which comes from the same region, is to the effect that five years ago Peter Horn sunk a well on his place and ever since there has been a continuous supply of pure, fresh water, no matter in what season of the year. Farmer Horn and others have always believed that this well tapped a subterranean river which is fed by one of the Great Lakes and the river is believed to flow in the Direction of Quincy. Neither of these lakes or rivers have been explored.*

From Quincy, we'll meander to the shore Lake Michigan. Whether the underground river makes such a loop or if we've discovered a tributary isn't clear, but either supports our hypothesis.

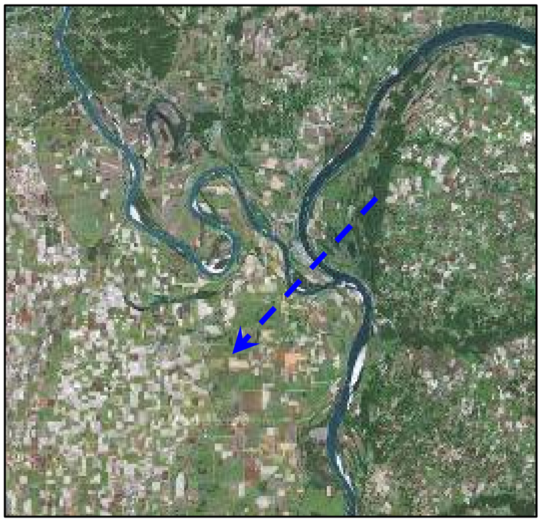
While most of our citations are from the archives, not all accounts of underground rivers are as old. From the May 31, 2005 edition of the Wednesday Journal, Oak Park and River Forest, Illinois, a northern suburb of Chicago,

> *In the 1920s, construction crews digging foundations for a handful of buildings uncovered water that appeared to be rushing through sand pockets, giving rise to a long-held myth that underneath downtown Oak Park runs a mysterious "underground river."*
>
> *Starting around 1925, the rumor grew out of a spate of ground breakings for various downtown area buildings.*
>
> *Water and sand were found a second time at the Community Bank site during excavation for an addition in 1952. Shortly thereafter, the Oak Leaves published a story, titled "Geologist unveils underground 'river' mystery." In the article, River Forest geologist Isabel Wasson (one of the first women to have a degree in petroleum geology) said the sand could be explained as the remains of the ancient glacial "Lake Chicago" beach.*
>
> *"The so-called underground river, revealed by excavations in Oak Park, is not a river running below the ground, but is water filling the porous spaces in a long, narrow sandbar which diagonals across Oak Park," Wasson explained at the time.*
>
> *Oak Park Village Engineer Jim Budrick, who said he occasionally gets some inquiries about the mysterious "river," said downtown simply seems to have a particularly high water table.*
>
> *"There's been an awareness [of the water] in downtown for a long time, but people are coming into contact with it more," Chen said, adding that some who cope with the geological conditions of downtown still call the phenomenon a river.*
>
> *Chen said the water "seems to have some flow to it," but he clarified, "this is not the Mississippi River drifting past the back door. This is not a raging river. It's water that is something a little less than standing if you encounter it," he said.*

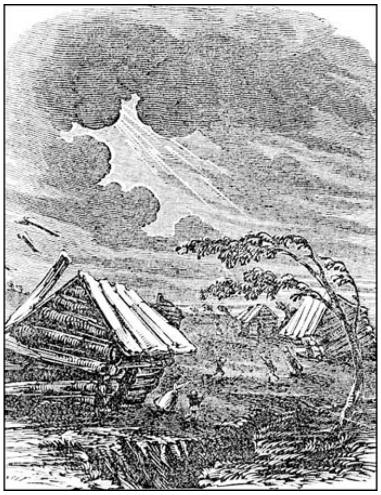
Moving yet southerly, there's been speculation about what's under the confluence of the Upper Mississippi and the Ohio Rivers. From the Crittenden Record-Press, January 7, 1909,

> *A government diver, while trying to locate an incline of the Iron Mountain Railroad Company, which disappeared at Bird's Point, Mo., a short while ago had discovered an underground river which runs under Bird's Point and Cairo and under the waters of Mississippi and Ohio Rivers near their confluences at right angle... This underground river is believed to be as large as the Mississippi, though with not so swift a current, and the water is of a different color and will not mix with the waters of the Mississippi. The scarcity of fish at this point is attributed to the new-found underground river where they are supposed to have gone.*

The aerial photo shows the confluence of the Mississippi River from the left and the Ohio River from the right. The dashed line suggests the underground river "as large as the Mississippi."



The New Madrid Earthquakes



There's nothing like a good earthquake to foster speculation regarding a mysterious subterrain.

The New Madrid Earthquakes of 1811 and 1812 were strongly felt over roughly 130,000 square kilometers, and moderately across nearly 3 million square kilometers. In comparison, the 1906 San Francisco earthquake was moderately felt over 16,000 square kilometers.

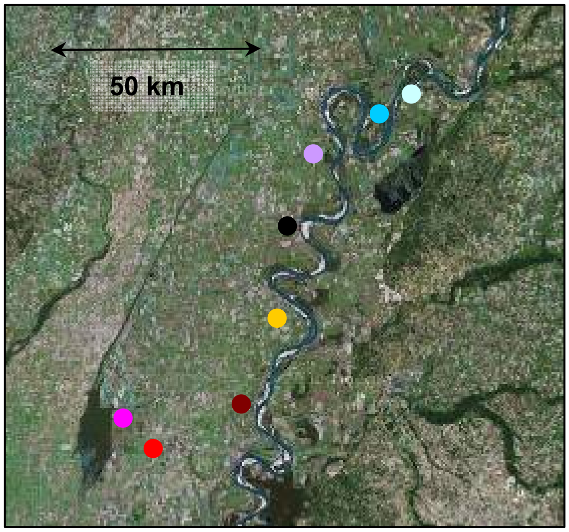
The events were caused by reactivated faults formed when North America began to split apart 750 million years ago. The resulting rift system has since been buried by younger sediments, some of which are karst.

The New Madrid earthquakes weren't volcanically-induced, but as the fiery subterranean engine of Kircher (Chapter 8) was yet in scientific vogue, accounts such as "Letter from Salt River," Home Journal, June 23, 1849, were common.

> *Then the whole valley was shaken by earthquakes which were so violent just below the mouth of the Ohio, that the old town of New Madrid was nearly destroyed; many boats laden with the products of the upper country were stranded or sunk; thousands of acres of forest were swallowed up by the river, and lakes were formed in its vicinity, where strange sounds have since been heard from the depths of the earth like the hissing of subterranean streams over beds of volcanic fire.*

While the earthquake indeed altered aquifer conditions, the subterranean magma never came close enough to the surface to boil groundwater.

The map below shows the New Madrid earthquakes' epicenters and hydrogeologic consequences.



	Event and Richter Magnitude	
🔴	December 16, 1811, 2:30 AM	8.6
●	December 16, 1811, 8:00 AM	8.0
🟡	December 16, 1811, 11:00 AM	8.0
⚫	January 23, 1812, 9:00 AM	8.4
🟣	February 7, 1812, 3:15 AM	8.8
○	February 7, 1812 River ran backwards	
🔵	February 7, 1812 Temporary waterfalls	
●	Big Lake, Arkansas	

Noting the reach of the river running backwards, we recall a similar event involving a punctured underground cavern beneath Louisiana's Lake Peigneur (Chapter 66).

A more permanent hydrogeologic change was that of Big Lake, Arkansas. Once a free-flowing branch of the Mississippi, Big Lake was changed to a shallow lake by the earthquakes.

The photo to the right is circa 1900.

According to the New York Times, April 15, 1928,

> *Big Lake, Arkansas, is one of the best known outlets of underground rivers. It is supposed that this lake has a connection with the Mississippi, as it rises and falls with the ebb and flow of the river.*

Given that the lake is embedded in riverine deposits, it is not difficult to believe that its elevation might increase at times of main-stem flooding.

"Many Underground Streams: Frequent Instances Where Rivers Sink into the Ground, and Form Rivers," in "Youth's Companion," Los Angeles Times, May 15, 1915, painted a more dramatic picture, not one of "ebb and flow," but a Poe-like maelstrom.

> *Big Lake, Arkansas, is supposed to have a subterranean connection with the Mississippi River, for the lake rises and falls with the rise and fall of the Mississippi. Off the Missouri shore the big river has a whirlpool that is a menace to small boats. The water always eddies about this whirlpool; but when the river is high there is an intake, and when the stream is low the water is driven upward. When the river is high, small craft have been sucked down and never seen*

> *again, and tradition says that even steamboats have foundered in this eddy. An underground stream from Big Lake is believed to emerge at this point.*

Given sufficient difference in water surface elevation, a river-to-lake conduit could, in theory, generate a Mississippi vortex, but Mississippi whirlpools are more easily explained by riverbank eddies. The reported lake-to-river conduit, on the other hand, makes no sense whatsoever for a sucking river whirlpool. That the nearest Missouri shore lies more than 100 kilometers distant only adds to the unlikeliness of the report.

In terms of hydraulics, Big Lake poses no mystery, but its association with the New Madrid earthquake is enough to fan the fires of subterranean supposition.

Scribner's Monthly

"Is There a Subterranean Outlet to the Upper Lake Region?" in Scribner's Monthly, April 1876, isn't just one more news item of underground mystery, a staple of the era's newsprint. For its day, "Is There a Subterranean Outlet..." was a work of investigative journalism. We'll go through the article piece by piece.

In answer to the title's query, yes, according to the article, there does seem to be such an outlet.

> *Whether the great lakes are the true reservoirs from which our Northern wells, springs and subterranean streams receive their constant supply of water, is a question of sufficient interest and significance to merit a thoughtful consideration. The data upon which the advocates of this theory found their conclusions are certainly manifold and forcible, and though there may be breaks in the line of evidence, the facts as now established would seem to favor the views which the author of this paper now proposes to define and defend.*

The article summarizes lake areas, impressively large acreages, and then continues.

> *There is a vast volume which, it is believed, is checked in its course over the surface to the south and east, by the elevations beyond Lakes Superior and Huron, and seeks an exit, as some think, by subterranean channels through the crust of the earth. It is also possible that some of the water escapes by contact with the deep recesses of Superior and Huron into their gigantic reservoirs; while other channels, fissures, and crevices in the earth's crust probably carry away in other directions, in their course, an unceasing flow for man's ultimate benefit and use.*

Water surface elevations are given and the case is made -- as we saw in the preceding chapter -- for a subterranean channel paralleling the surface course.

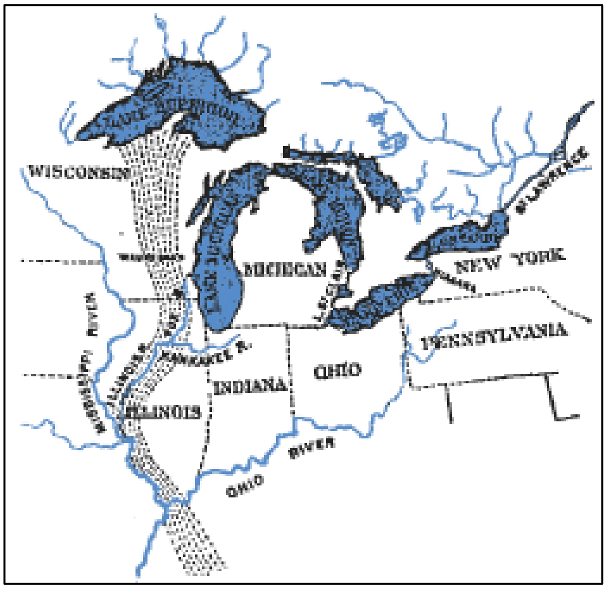
> *A subterranean channel may connect Superior and Huron with Ontario, giving to the latter, through this source, to be discharged by the St. Lawrence, a greater volume than is given through St. Clair or the Niagara. It is also a well-demonstrated fact that the volume of water escaping from the lakes through the mighty St. Lawrence is far greater than the amount discharged from the upper lakes into Ontario by the proper channels -- the St. Clair and Niagara; and it is also well settled that the supply to Lake Erie from the St. Clair is about equaled by its discharge through the Niagara; showing that it receives from no subterranean source any perceptible surplus of water.*

Here, however, the article introduces another, but non-exclusive possibility, that of a southern exit.

> *There are those also who entertain the belief that while Lakes Superior and Huron are supplied largely through such subterranean channels on the one hand, they suffer severely through losses by similar channels at some point in their vast expanse...*
>
> *And if it can be demonstrated as to what these sources of supply could then muster up, and that the same average discharge still continues through other but unseen channels, then is it not possible that the causes which brought about this recession of the waters of the lakes, and finally closed this old outlet, wrought other and corresponding changes by which a new passage was supplied for the escape of the outpouring of this region -- in other words, may not*

> *the same territorial convulsions which elevated the plateau at the foot of Lake Michigan, and shut off the outflow into the valley below, have opened up subterranean passages through which these waters find such easy access in their course to the sea?*

According to Scribner's, Lake Superior and possibly Lake Michigan may outlet into the Illinois Valley and from there, on southward. The article's "Track of Subterranean Outlet from Lake Superior" graphic is shown to the right.

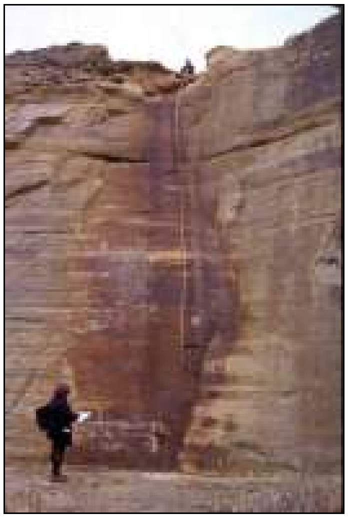


Scribner's recalls the legend told by Ottawa chief Shabbona of a Lake Michigan outlet to what now would be the Kankakee River, tributary to the Illinois, tributary to the Mississippi. The Chief's name, we must note, is remarkably similar to "Shambhala," Chapter 71's Buddhist kingdom of the inner world, but we'll not pursue the possible connection. The article continues,

> *A trip over to the south-east comer of Lake Michigan, near Michigan City, reveals to us huge mountains of sand which have been drifted about for years, and much reduced in height.*
>
> *This sand is from the lake, and is cleanly washed, and interspersed with shells of the present period. There they lie, some goo feet high; many far inland, and all in the track of those fierce gales which swept the lake from the north-west. These are not mere heaps of loose sand, the natural accumulation of successive storms, but mountains.*

Below is a 1950s postcard of Indiana Dunes State Park on Lake Michigan.

Indian Dunes State Park



Buffalo Rock State Park

> *Far inland, and directly in the track of these prehistoric gales, a broad expanse of level land appears; very unlike the usual formation, as seen throughout this great country. The surface resembles the long unbroken swell of the Pacific. For miles away, and stretching far into Indiana, the surface recedes and swells in a continuous line, each line having a trend north-east and south-west, marking with exactness the great swell as it coursed over shallows...*

We must note that such inland sand dunes are still derived from Lake Michigan, but at the time of the writing the formation may have seemed like undulations in an ancient streambed.

> *Nowhere along this valley are there indications more striking than at Buffalo Rock, five miles below Ottawa. Here we not only have the water lines in bold outline, but the depth of this great stream becomes plainly apparent. Here the perpendicular face of the rock stands fronting the stream. Though somewhat washed and weather-beaten, the lines are well defined.*

The above photo of Buffalo Rock stratification -- water created, to be sure, as sandstone formation is a sedimentary process -- isn't, however, evidence of catastrophic flooding. It's a story of lamination.

We may be confused as to why Scribner's devotes so much discussion -- much of which we've not reprinted -- to a surface river that is no more, but then we see the logic.

A mighty river once flowed south from Lake Michigan.
Geologic uplift blocked the outlet.
In relation to upper lake volume, today's Lake Michigan discharges relatively little to Lake Huron.
Therefore, much of Lake Michigan's outflow must be where we now can't see it.

And thus in the article's title, "Subterranean Outlet."

> *It is a well-known fact that throughout the extent of this valley, at no great depth are vast basins and subterranean streams of pure water, in all respects corresponding in its general characteristics to the water of Lake Superior, containing the same ingredients in solution, save where, in its passage to the surface, it may have passed through the coal measures, and become impregnated with sulphuretted hydrogen.*

As to how this subterranean route evolved, Scribner's didn't have a full understanding of karstology, but we can see the rudiments as it cites geochemistry.

> *Or when, coming, as it does, from its source, charged with carbonic acid, it may have passed, in its course to the surface, through the various limestones, and become charged with the carbonates of lime or magnesium; or, again, by infiltration through a thin seam of bog ore or iron pyrites, it springs forth, bitter with impregnations of iron or its sulphates. But, where it finds its way to the surface through the sandstone and supernatant strata of gravel, it becomes shorn of its chemical properties, and bursts ort in its virgin purity from the hidden recesses. The unlimited outpouring of this crystal water is too well known here to require comment. Away up in Wisconsin, in the track of this under-ground current, the waters reach the surface in unprecedented protrusion. At where the Niagara limestones crop out in strange contrast with the regular stratifications, it comes rushing to the surface in huge volumes.*

The last chapter's from-whence-the- Great-Lakes fish? perplexity provided more evidence for subterranean passages.

> *The writer was present at the digging of one of the many wells at that place during the summer of 1874 when several live fish came through a hole made in the rock with a crowbar. The flow of water was so great -- at a depth of eight feet -- that the workmen were compelled to cease. As there was no means by which these fish could have reached this well other than the one mentioned, it is evident that it had communication with some subterranean current where fish existed.*
>
> *At Lake Geneva, in Wisconsin, it is well known that a fish, known as the Cisco, comes and departs at regular periods every year; it remains but a few days and is gone.*

> *These same fish are found in Lake Superior, only, and it is believed by many that there is a subterranean passage by which they come and return.*

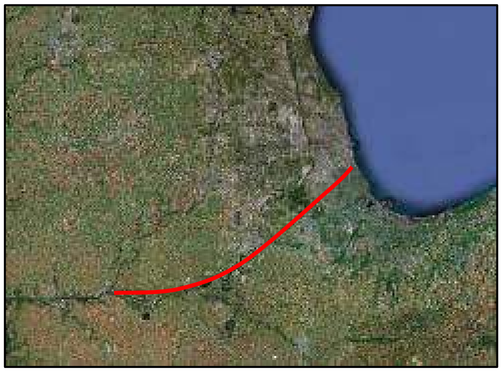
The why-the-tides? quandary was good for a paragraph.

> *It is a fact well known to many who have visited Northern Wisconsin, that there are lakes near Superior whose waters rise and fall with those of Superior. When the wind is strong from the east, the waters of the western shore pile up, and a corresponding rise occurs in these smaller lakes, while a change of wind brings about a corresponding recession.*

And the from-where-come-artesian-springs? question provided more to ponder.

> *All along Lake Michigan, as in the region of Superior, we find this water springing to the surface, save where it is checked by a heavy substratum of clay. It is reached by artesian wells at Chicago, Joliet, Morris, Marseilles, Ottawa, and far down the valley. At Marseilles it is reached at a depth of from eighty to one hundred and fifty feet, and comes in volumes. At Debolt's Springs, near Ottawa, it comes to the surface in such quantities that, were it not for the fact that , the outlet is so near the edge of the river, it might well be utilized for manufacturing purposes. At Ottawa it supplies a part of the city, and the railroad stations have their wells which flow without ceasing. Here are located upward of twenty artesian wells, each seeming to outdo the other in the voluminous delivery of its pure crystal water. And here on the bank of the old Illinois, opposite the junction of the Fox River, are the celebrated mineral springs of this valley.*

The referenced Ottawa-to-Chicago line of artesian wells is shown to the right. The municipality of Ottawa has not the reported 20, but rather 150 such springs. The "celebrated mineral springs" produce "Sanicula" water, a homoeopathic remedy marketed today for enuresis, seasickness, constipation and rickets.



Scribner's could even recall the idea of floating islands, a railway concern covered in Chapter 74.

> *Along the valley, lower down and near Peoria, for many miles, vast tracts of land are rendered useless in consequence of the great rush of these waters to the surface through the supernatant seams of gravel, endless swamps, fields of wild rice, and, in some places, whole tracts of densely matted bog and thicket, oftentimes covered with a sparse growth of timber, are buoyed up by the gushing waters, and, like floating islands, remain suspended there; and, after a hard winter has left the mass frozen, the heavy gales of early spring sway the entire tract back and forth until the winds subside. A long pole penetrating this tenacious mass glides down uninterruptedly through several feet of clear water, until finally arrested by the hard bed of gravel below.*

The article then speculates,

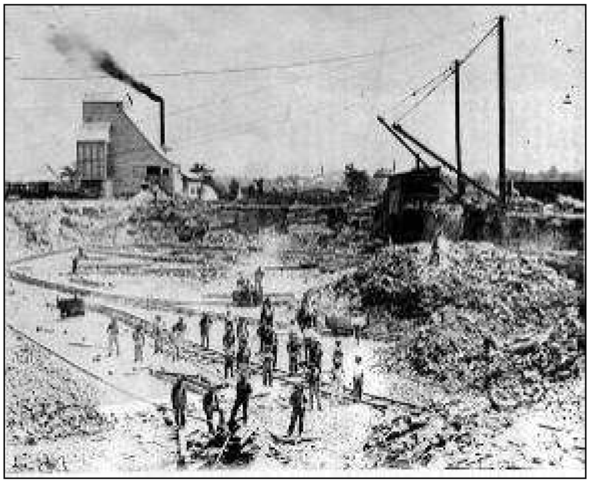
> *Farther down the valley, and, we think, in Schuyler County, near the river, the sandstone formation crops out in bluffs of various altitudes; and, at a point where a saw-mill has been in operation for some years, a natural outcropping of very wonderful character is seen. Here, from the very interior of the rock, comes a torrent of clear, pure water, falling about seventy-five feet has been used for years as a water power, and a more valuable one is seldom found. Around the mouth of this subterranean torrent, which will average some eight cubic feet of solid water, innumerable specimens of fossils are found, and basketfuls have been picked up here at one visit; from this it is very evident that the subterranean current is in the Old Red Sandstone,*

> *and, in its escape to the surface through the fissures and crevices, it passes through the fossiliferous rocks, which are gradually being disintegrated by the constant flow. Such is the case at Waukesha, where the Niagara group of fossiliferous limestones comes to the surface.*

There are no major waterfalls in Schulyer County, but to the east and near the Illinois River are falls set in sandstone, some as high as 80 feet. The falls at Horse Shoe Canyon at Starved Rock State Park is shown below in the 1904 postcard as well as a photo of a Waukesha limestone operation of the same vintage.

HORSE SHOE CANYON, STARVED ROCK, ILL.

Horse Shoe Canyon



Waukesha limestone operation

Scribner's concludes

> *To give an account of the many and though not peculiarly interesting cases in which these salt, waters make themselves manifest at the surface in this valley, would require a volume; but these are mere finger-marks of the vast of currents which rush along in this track wells are through the subterranean channels.*

In short, "Is There a Subterranean Outlet to the Upper Lake Region?" employed most of the folk arguments in favor of underground rivers:

> Native American lore,
> Mysterious waters in the profundity of caves,
> Unexplained fish,
> Inland tides,
> Great artesian wells,
> Water lost and found,
> Evidence of ancient floods and
> Earthquakes.

All are arguments we've seen employed at many times in many places, but here, as one big package.

"The Great Lakes," Messenger, July 26, 1876, was in full accord.

> *Martin B. Howell, Jr., in Scribner's Magazine propounds the query, is there a subterranean outlet in the upper lake regions? and brings forth evidence to show that there is... The data upon which the advocates of this theory found their calculations are certainly manifest and forcible; and though there may be breaks in the line of evidence, the facts as now established would seem to favor the views which the author of this paper now proposes to define and defend.*
>
> *Lakes Superior, Huron, Michigan, Erie, and Ontario... make a very formidable area of fresh water receptacles for this chain alone; while there remain yet an innumerable multitude of smaller but similar bodies dispersed through the great northwest territory of the Hudson Bay*

> *country. Here is a vast and comparatively unproductive region, penetrated in every direction by streams of greater and less magnitude, interspersed with lakes und bays, which in many cases cash their broad mantle of water for hundreds of miles... While much of the outpouring of these waters is directed toward the Polar Sea,*

"Toward the Polar Sea?" That's one we've not pursued, but we'll let if pass. Back to the passage,

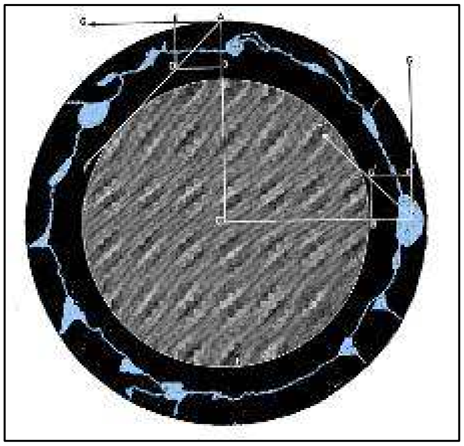
> *and through the valley of the Mississippi, yet there is a vast volume; which, it is believed, is checked in its course over the surface to the South and the East by the elevations beyond Lake Superior und Huron, and seeks an exit, us some think, by subterranean channels through the earth's crust. It is also possible that some of` the water escapes by contact with the deep recesses of` Superior and Huron into their gigantic reservoirs; while other channels, fissures, and crevices in the earth's crust probably carry away in other directions, in their course, an unceasing flow for man's ultimate benefit and use. The depth of penetration of' some of this chain of great lakes into the solid matter of the earth's surface affords a good illustration of their adaptation as recipients of a great influx from subterranean sources.*

While "Is There a Subterranean Outlet to the Upper Lake Region?" can be dismantled in the light of geological knowledge, its case for the affirmative is a good comprehendum of late 19th-century popular opinion.

The Scribner's feature also engaged the era's increasing-pursuit of geophysical basis, albeit fallacious or sound. Nelson W. Green's "Why Do Springs and Wells Overflow?" Popular Science Monthly, November 1879, picked up on the subject.

> *Scribner's Monthly has a very interesting article by Martin A. Howell, Jr., entitled "Is there a Subterranean Outlet to the Upper Lake Region?" While we are sorry to quarrel with Mr. Howell as to his conclusions, we are very happy to accept his facts.*

Green agrees with the existence of subterranean channels, but disputed that such channels operate under gravity alone, citing a score of water bodies -- many of which we've encountered or will encounter in other chapters -- which, in his opinion, are significantly larger in volume than could be sustained by their surficial watersheds.



The quandary's solution, Green contends, is found in physics. Referring to the diagram, he attempts to prove that water enclosed within the earth's crust will naturally flow outward.

> *The resultant of the earth's centripetal and centrifugal forces acts impulsively upon the subterranean water-deposits, and tends to force them into and through the natural channels of the earth's crust.*

Green's physics, however, didn't find many takers, Joseph J. Skinner being a vociferous respondent. Excerpted from Skinner's reply in Popular Science Monthly, January 1880,

> *Mr. Green's two propositions that differ most essentially from the commonly accepted theory of artesian wells are*
>
> *1. That the flow of water from them is not due to pressure transmitted from water at a higher level, but to "some force not yet identified" ; and,*

> *2. That the supply of water for such wells, and indeed for ordinary springs, comes from "subterranean waters, seldom if ever influenced by rains."*
>
> *Mr. Green identifies the required force as "the resultant of the earth's centripetal and centrifugal forces," and, having found that the tendency of this resultant is to force water* ***out****, wherever there is an opening upward in the earth's crust, of course it is necessary to suppose that there is a plenty of subterranean water already down. He seems to think it entirely unnecessary to suggest any means of replenishing the supply of this subterranean water, or even to imagine that it could ever need replenishing.*
>
> *Without insisting further on the fact that the rain-waters, dews, and snows falling on higher grounds must be sufficient to account for all flowing springs and wells (except, possibly, such cases as the geysers), let us see how Mr. Green's subterranean water-deposits are to be driven to the surface of the earth by his "newly discovered force."*
>
> *As a specimen of mechanical exposition this is almost unique, but it is too ludicrous to mislead. In point of fact, as every schoolboy ought to know, the centrifugal force due to the earth's rotation, on a particle at any place on the earth, does not act in the direction of the tangent to the earth's surface, but in the outward direction of the radius of the circle of latitude of the place; a diagonal of a parallelogram is frequently shorter than either of its sides; the centrifugal force acting on a particle, due to the rotation of the earth, is never more than about the 1/289 part of the force of gravity; the direction of the resultant of this centrifugal force and of gravity is always very nearly that of gravity; the intensity of this resultant is always less than that of gravity; and instead of increasing with the distance from the center of the earth it decreases. Perhaps these are points that make no difference in the value of Mr. Green's theory; but still they are worth the consideration of any one who proposes by contraries to upset the doctrines of such men as Arago, Faraday, Garniei, and Halley.*
>
> *Not even the wonderful fact mentioned by Mr. Green, that "by inclosing an overflowing spring tightly, and allowing the enclosure to be terminated by a tube with an opening carried to a level below the fountain, the flow was increased" -- not even this will overthrow the principles of mechanics, as anyone who ever understood a siphon would know of artesian wells.*

As we're aware from Chapter 44, an artesian well might spring from an inverted siphon, but not as the last sentence might suggest, a true siphon.

> *Without expressing an opinion of my own as to whether there really is or is not a subterranean water-channel between Lakes Superior and Ontario, it is evident enough that, even if there is, its size and character, as being more or less obstructed by solid or porous materials, together with its length, would have some influence in determining the quantity of water which could flow through it, even with a difference of water-level over its extremities equal to three hundred and sixty-five feet. Unless, therefore, Mr. Green's "newly discovered force" should suddenly cease to make Lake Superior an "overflowing spring of subterranean water," or, rather, unless the region from which Lake Superior gets its water should be deprived of its yearly rains, we need not immediately look for a common level of the water in Lakes Superior and Ontario.*

In short, while there may or not be subterranean conduits, the earth does not spin water up them.

Other Speculations

Some writers supposed other routes of subterranean runoff from the American heartland.

In his report Account of an Expedition from Pittsburgh to the Rocky Mountains, Performed in the Years 1819, 1820. Compiled from the Notes of Major Long, Mr. T. Say, and Other Gentlemen of the Party (1822), Edwin James, botanist and geologist to the party, speculated that rainwater sinking through the Great Plains soil might "be collected into rills, and even considerable streams" upon encountering a resistant stratum of rock, and flow in this fashion "in the direction of the general inclination of the country to emerge in the form of huge springs" in the area of the Ozark Mountains.

"A Romantic Voyage," The Round Table, A Saturday Review of Politics, Finance, Literature, Society and Art, March 20, 1869, had this to offer.

> *It is surprising, after the many exploring expeditions and prospecting parties which have penetrated into our mountain fastnesses in the West, how superficial is our knowledge of those remote districts. The fields are indeed white unto the harvest, but the laborers are few compared with the extent of territory yet lying an almost terra incognita, and strange discoveries will doubtless yet be made, when parts now difficult of access shall have been minutely explored. We confess, however, that our credulity is sorely taxed by the startling assertion that Mr. Catlin, the prairie traveler of Indian notoriety, has announced the existence of a great river, larger than the Mississippi, flowing under the Rocky Mountains; Yet such an hypothesis -- for it is nothing more -- is not so improbable as might at first be imagined. Many entirely subterranean rivers we know exist, running through deep mines and caves, coming and going no one knows whence or whither,*

We must applaud the picturesque "coming and going no one knows whence or whither." Modern journalism's lost such flair. We continue,

> *while others, in parts of their career, burrow through wound natural tunnels, to reappear as suddenly miles away; but that a river larger than the Mississippi, flowing under any mountains on the North American continent, could have existed so long without being discovered, is simply impossible, and we shall await with some curiosity the publication of the evidence upon which this singular speculation is based. Without any fanciful theories or colored exaggerations, Western rivers do present many features of peculiar interest, well worthy of examination and study; one of the most singular being the mountain defiles through which, for many miles, they often run.*

Might the subterranean pathway pass through New Mexico? "Unexplored Cave at the Gran Quivira," Las Animas Leader, January 29, 1875, provides some insight.

> *We have just had an interview with Mr. J.S. Poor, one of the parties spoken of in the New Mexican, and from him we glean the following. Himself and Mr. Brainard found the entrance of the cave situated upon the top of a ridge... They then proceeded into the cave a short distance lighted only by matches, when they heard unearthly noises, as described in the New Mexican, and withdrew for the night. The next morning the noises were the same.*
>
> *Upon our suggestion that the noises arose from a subterranean stream, he informed us that he could discover nothing in the sound that indicated it. Yet we are satisfied that such must have been the case. We are of the opinion that it is the same stream that runs through the cave near Fort Stanton and breaks out just below.*
>
> *If our theory is correct, we may yet see that stream brought to the surface by artesian wells and a fine agricultural section opened and improved by its means.*

As Ft. Stanton 120 kilometers from Gran Quivira, it's a lengthy tunnel.

Suffolk County News, Aug 4, 1894, melds western legend and a reasonably-correct description of the Ogallala aquifer discussed in Chapter 38, Hydrogeology.

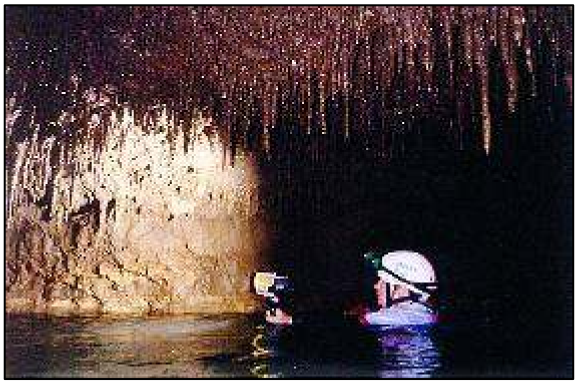
> *Believed to Come from Rivers Which Drain the Underground of the Rockies.*
>
> *It has often been remarked that the Missouri, which is the principal drain of the vastness of all North American basins, is but a small stream in comparison with the country which supplies it, and the conclusion seems irresistible that there are subterranean channels by which its waters are carried off.*
>
> *The underground rivers of Dakota, from which the extensive artesian water supply of that region is obtained, are believed to be directly connected with the upper Missouri River where it passes through the canyons of the mountains. It is known that there are enormous subterranean rivers flowing under Texas, for they have been tapped by artesian wells at many places, and notably at Waco. There are in the heart of the continent several basins of great*

> *extent which receive large drainage from the surrounding country, but have no surface issues. There is good reason to believe that enormous volumes of water find their way into every sea by submarine debouchments and the conformation of the continent makes the Gulf of Mexico a most likely recipient for such discharges.*

From "Exploring an Underground River. Remarkable Watercourse beneath the Surface of Texas," Ogden Standard, July 14, 1891,

> *Kendall County possesses one of the wonders of the world. The winding cave, with its underground river, which was explored a short time ago, has been found a wonder of the first magnitude...*
>
> *It was understood that a boat would be on hand to convey the explorers over the dark river, but in this they were disappointed. Lumber had been procured with which to build a raft. This craft was constructed inside the cave's mouth and at the point where the water began to deepen, but it was found inadequate to carry even one passenger, and could therefore be used only to carry some of the lights necessary to search out the way...*
>
> *There can be seen large stalactites hanging down from the domes above on either side of the wide and lofty passage until their nethermost tops touch the inky surface of the water that flows black and impenetrable through the clear cut channel of this subterranean river. At other places the stalagmites rise from the river's bottom and point with snow-white fingers over the water surface to the domes overhead...*
>
> *After traveling a distance of about 200 yards, and turning a sharp angle that cut off the last ray of daylight, the exploring party reached the edge of the water, where the entire floor of the cave is occupied by the stygian stream. Here the raft was launched and proved to be almost useless, and here the hardy and venturesome explorers stripped themselves and waded into the water and chattered their teeth. It was a great pity that no boat was there...*
>
> *The party continued the journey into the bowels of the earth, sometimes wading and at other times, swimming, for a depth of ten feet of water was found in several places... But the party went bravely on, floundering to and fro and trying to keep warm by exertion and good-natured romping and jostling of each other...*
>
> *There was one feature especially worthy of notice and consideration, and that was that the farther the explorers went into the earth and the farther they followed the sluggishly flowing river, the deeper became the water and the wider the channel and more expansive the black void of the cave...*
>
> *Far away could be heard a low, deep murmuring as of distant thunder, now advancing and then receding, while around and over the explorers, heads were damp, cold, silent walls, dark, dreary, and despotic in their awful grandeur.*

Honey Creek Cave, which this appears to be, is the state's longest at 33 kilometers.



The river-under-Texas report was widely circulated. From the Phelps Citizen, September 11, 1911,

> *According to geologists, the largest underground river in the world flows from the Rocky Mountains underneath New Mexico and Texas, emptying itself in the Gulf of Mexico. The river is thought to be in places several miles wide, and it is believed that it feeds rivers that flow on the surface. The artesian wells of Texas are said to take water from this river, often from 800 feet below.*

Change a few words and we have the October 2, 1911, Sabbath Recorder.

> *Geologists are claiming that the greatest underground river in the world flows from the Rocky Mountains underneath New Mexico and Texas, emptying itself in the Gulf of Mexico. This river is thought to be in places several miles wide, and it is believed that it feeds rivers that flow upon the surface. The artesian well belt of Texas is pointed to as the uplifting of the water from this river, often from 800 feet below.*

Or from the Tombstone Epitaph, January 14, 1912,

> *Geologists are claiming that the greatest underground river in the world flows from the Rocky Mountains underneath part of Arizona, New Mexico and Texas, emptying itself in the Gulf of Mexico. This river is thought to be in places several miles wide, and it is believed that it feeds rivers that flow upon the surface. The artesian well belt of Texas is pointed to as the uplifting of the water from this river, often eight hundred feet below.*

Or as simply stated by the Wichita Daily Times of October 5, 1911,

> *A subterranean sea has been discovered under Texas, but whether it is water of brimstone is not yet apparent.*

As brimstone is a name for sulfur, however, the nose would have answered the question.

"Underground Rivers of Arizona," Mohave County Miner, January 20, 1912, heralded a bright future.

> *Recent investigations of the underground waters of Arizona and Texas, completed by the geological survey, his developed the theory that there is a great underground river extending through Arizona and Texas, and emptying into the Gulf of Mexico. No attempt has yet been made to secure water from this great river, but as it is being traced out it is probable that it will be used for the irrigation of a great acreage, if it can he made available. The survey has for many years been investigating the underground flows of the different states and its discoveries have been of material ad vantage in the securing of artesian water in sections heretofore believed to be waterless. Should the further investigation of the underground flow prove that waterless sections of our new state can secure artesian water it will make available some of the richest lands in the world. The peculiar ebb and flow of water in the Silver Creek section of this county, would lead to the belief that there is a flow from some point far to the north, which rises*

> *with the Colorado River and forms springs high on the mountainside, to diminish and fail as the river subsides late in the summer.*

"Strata of Water" in the Florida Mirror, March 24, 1891, saw great advantage for the West.

> *The theory has been advanced that the earth abounds to an extent more than is now believed in underground rivers which flow in various directions at different depths. What becomes, for instance, of the waters that melt from the everlasting snows of mountain tops? They do not all run off upon the surface, that is plain. Rivers have frequently been discovered in caves far under ground, rivers that had, as far as could be found, no outlet, yet they flowed on with a current as swift as that of streams above ground.*
>
> *One explorer of subterranean waters claims that there is at least as much water in the underground river streams and lakes as there is upon the surface. He himself is confident that he has located and traced for a distance of eighteen miles one stream in Dakota which is from ten to fifty-five feet wide and over four feet deep.*
>
> *From these subterranean streams the water for irrigating the arid plains of the west will be obtained, it is expected. In mountainous regions the subterranean streams will he found to take their origin. If, then, shafts are sunk and tunnels dug in the proper direction an exhaustless supply of water can be obtained from this underflow. The underflow of water is, in fact, now earnestly engaging the attention of the United States department of agriculture.*

To this point, the article is fairly standard in the enthusiastic promotions of the era. Here, however, the writer ventures further, implying that the vast underground caverns might be a suitable shunt for those pesky Mississippi floods.

> *Artesian wells, tunnels and- reservoirs near the head waters of rivers are the means looked to to irrigate the great west, and perhaps in time many parts of the east, too. Persons with brains in their heads are beginning to wonder seriously why the great rivers like the Mississippi, Ohio and Missouri should be unchained and play havoc with the country along their banks when the water might be drawn off' into great reservoirs at flood time and kept to irrigate parched fields in the dry season.*

Not all were equally entheusistic, however. We quote the Coconino Sun of Flagstaff, Arizona, September 28, 1901.

> *Some one desiring to exercise their imaginative powers sent a yarn to the El Paso Times to the effect that a vast underground river had been discovered near Safford, and that our sister city was all excitement and jubilation. The article has been copied and recopied all over the territory, and should now be branded and turned out. The valley has been as sleepy as an "amen corner" in church. It would take two or three such rivers us the imaginary one described to stir up anything resembling excitement around here.*

But as we seen time and time again, beliefs resurge, as illustrated in "Disaster, Part 1, Lubbock is Running out of Water," Texas Monthly, December 1974.

> *But even if the available land had been endless, that rush would be dwindling nevertheless. There are still some mossback farmers in the region who will tell you that the Ogallala aquifer will never run dry. "Fills back up when it rains," a terse cotton farmer from Floyd County said. But those poor souls are clinging to an illusion that in slightly different form was widely believed even as late as the Forties -- that the Ogallala was inexhaustible because it was actually an underground river. Its source was supposedly either melting snows in the Rockies or melting glaciers in Canada.*

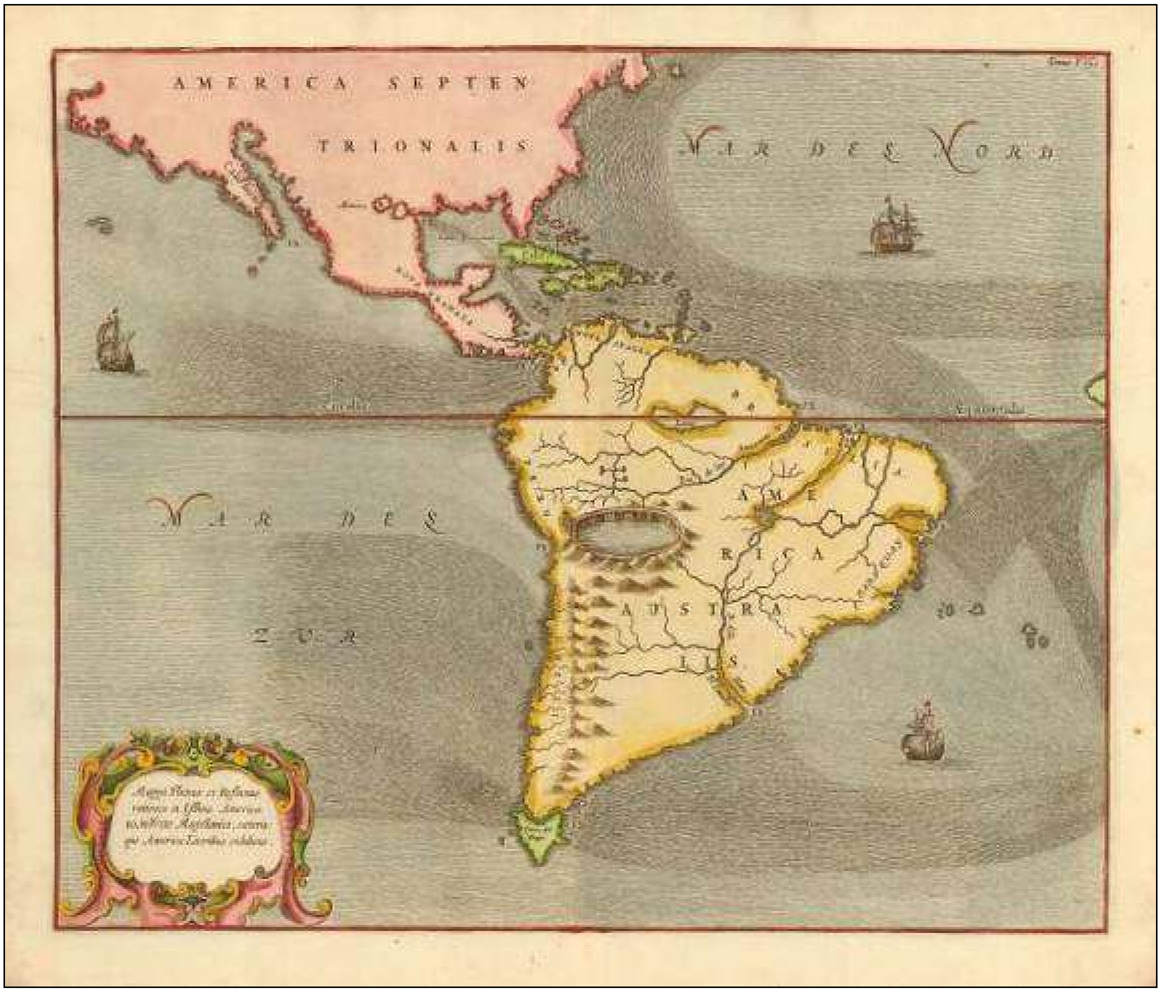
Perhaps the flow crosses below the Rio Grande.

An abundance of water beneath the Texas plains was recognized, but inadequately understood. "Underground Texas River, Enormous Flow Several Miles Wide at Depth of 800 Feet Traverses State," Washington Post, May 8, 1911, did little to help the latter.

> *For a time there was a theory that a portion of the southwest section of the State was underlaid by a subterranean lake, but this theory has given place to the later idea of an underground river.*

Neither the Ogallala (Chapter 38, Hydrogeology), the Edwards (Chapter 48, Diversity in Darkness, Texas Ecology), nor any other Texas aquifer is a river or a lake. They're vast geological strata that happen to be wet, but that doesn't make news.

Nowhere in our journey do we seem to evade Father Kircher. "Mappa Fluxus et Refluxus rationes in Isthmo Americano," in his d'Onder-Aardse Weereld (1682) shows Lake Titicaca as the crater headwater of the Amazon, the Andes as a range of live volcanoes, and Mexico City floating on one of two lakes connected underground to the Gulf of Mexico. Note the turbid plume.



We'll encounter yet more of this great subterranean vein of the American heartland in our concluding chapters. Citations to come include:

> *Some of the maps consulted... showed the lake in the vicinity of where Salt Lake now is, it was reported as a long lake, three of four hundred miles in extent, narrow with two outlets... either apparently larger than the Mississippi River.* -- Chapter 90, Why Do We Believe What We Believe?
>
> *I am convinced that the river which brought me here flows on into the Gulf of Mexico, and that, sooner or later, my log will be picked up. Perhaps this river is really the source of the Gulf Stream.* -- Chapter 86, The Rio San Buenaventura

Conclusion

If in fact no Mississippi-scale subterranean river actually flows from the American heartland, we're not distraught. Where geology doesn't provide, we have our minds.

As T.S. Elliot wondered, “At what point in its course does the Mississippi become what the Mississippi means?”

To which Mark Twain's might have replied, "It's not about the water's depth, Huck; it's when our imaginations draw us into the current."

CHAPTER 80
TO LIE LIKE A MULHATTON

"To lie like a Mulhatton" -- prevarication in the superlative degree, a tall tale

This chapter deals with the subterranean river beneath Birmingham, Alabama.

What subterranean river? we may ask.

The one below the Pittsburgh of the South, we are informed, a well-known geologic feature, albeit one eluding confirmation.

Consider, for example, this excerpt from the Birmingham Iron Age, August 5, 1886.

> *Every place has its mystery. Birmingham has its underground stream of water, and other places have their haunted houses, but our county has lately been visited by a mysterious occurrence which baffles the skill of those who have attempted to unravel it.*

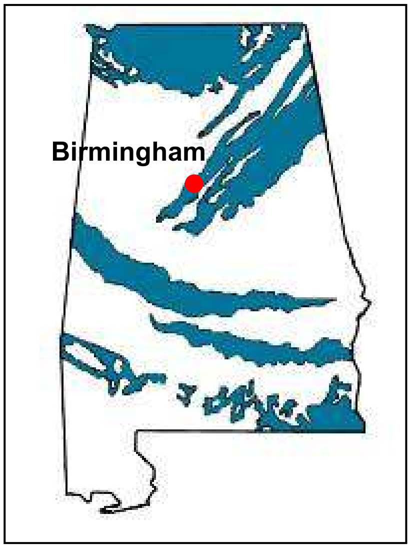
The Age then describes the inexplicable bombardment of a remote cabin by falling stones, but our interest is in article's the lead-in, Birmingham's mysterious underground river.

Knowledge of the underground stream predates European settlers, it seems. From The Valley and the Hills: An Illustrated History of Birmingham & Jefferson County (1981) by Leah Rawls Atkins,

> *The early settlers of Jefferson County knew the Indians well, and as time passed and the tribes vanished from the valley, they shared their childhood stories of Indian legends with their children. One of the most popular stories tells of two Indian braves*
>
> *Another Indian legend of the valley told of an underground river that ran the length of Jones Valley. Indian children, when they came into the white settlements to trade at the stores, would play with pioneer children and tell them stories of how they had come from a long canoe ride on this underground river.*

But indeed, the story is much more than vaguely-recollected lore.

To understand the nature of subterranean boating beneath Birmingham, we should be aware of two facts, one relating to geology, the other, to a particular personality.



Fact 1: Birmingham's Karst

As indicated by the map of Alabama's karst, the floor of Jones Valley consists of limestone. There would be karst caverns and with them, some likelihood of subterranean water.

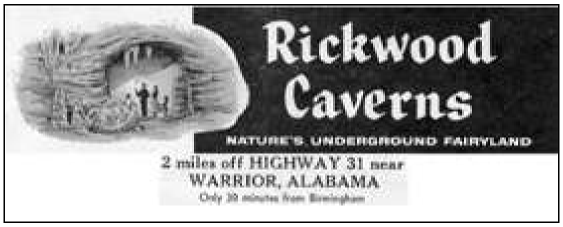
That much said, however, the Birmingham environs don't rank high in the ranks of karst wonderlands.

The city has had its share of sinkholes, "Man's Front Yard Goes Underground," Tuscaloosa News, January 15 1961, providing an example.

> *A Birmingham resident said Saturday that about 25 square feet of his front yard and two pieces of shrubbery disappeared in an underground river Friday night.*
>
> *David Holland of the Midfield community said the water is about 15 feet below ground level and that the river measured nearly 70 feet deep at that point.*
>
> *Neighbors speculated that the river probably stems from a spring a few blocks away which dried up a few years ago.*

But in the spectrum of south-eastern United States sinkholes (Chapter 40), Birmingham's instances are not particularly noteworthy.

The Birmingham area sports two tourist caves, each terminating in a small pool, but neither fed by a flowing stream. Both caves have been popularly said to extend to underground channels, but hydrologic evidence fails to support the supposition.


Rickwood
Caverns
NATURE'S UNDERGROUND FAIRYLAND
2 miles off HIGHWAY 31 near
WARRIOR, ALABAMA
Only 30 minutes from Birmingham

Rickwood Caverns
State Park
60 kilometers north of Birmingham

Length 1,600 meters. Blind cave fish. A 20-meter deep underground pool from which there is said to be a connection to an underground river. Divers exploring the pool prior to 1974 found nothing.

Rickwood
Caverns
$8.00

DeSoto
CAVERNS
Family Fun
Park
D
Catch it!
The
Butterfly
House

DeSoto Cavern
Private Enterprise
60 kilometers south-east of Birmingham

Formerly known as Kymulga Cave. 12 stories high main chamber. Legend that the cave extends for kilometers, but it ends at a small pool 300 meters beyond the main chamber.

DeSoto
Caverns
$9.99

The city has had its share of foundation flooding, but little different from the building history of most cities. It's why excavation contractors have pumps.

Access to an "underground stream" near Highland Avenue and 12th Avenue South was sealed by the city in the early 1900s because it posed a danger to children.
Construction of the Tutwiler Hotel in 1914 was delayed by the need to add steel beams to the foundation in order to span a subterranean cavern.
The never-completed Roden Hotel was limited to a single-story basement because of groundwater.
The Florentine Building (1927), which was planned to be ten stories, only went to two stories, partly because of the expense of shoring the foundation.
Excavation for the Federal Reserve building's 1957 annex had to be pumped out continuously during construction.
Construction of the Daniel Building in 1967 was delayed as engineers searched for areas of solid bedrock between limestone cavities on which to erect its caissons.

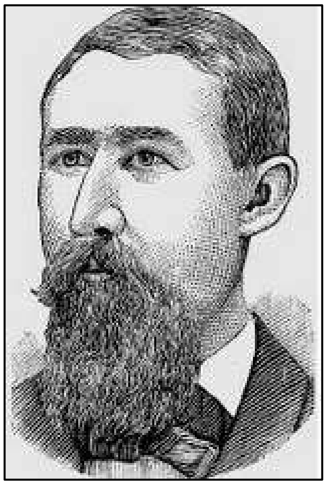
Testimony in "Letter from the Secretary of War, Transmitting, with a Letter from the Chief of Engineers, Report on Preliminary Examination of Valley Creek, Jefferson County, Ala., June 6, 1919. -- Referred to the Committee on Rivers and Harbors," United States Congressional Serial Set, Issue 7643, refers to the Birmingham underground river.

> *Further Statement of T.A. Weller, Member of the Birmingham Chamber of Commerce.*
>
> *Right here are artesian wells [indicating]. They went down to 130 feet and then put powerful machinery on them to get them lower, but they could not go lower. The water is there. The president of the pipe works told me that if you go down 30 feet you will strike an underground river. That would give us all the water we want at this point here.*

Mr. Weller can tell Congress what he likes, of course, but his choice of words is hardly proof of anything resembling a river.

The fact that the Birmingham region has some of karst features is not ipso facta geological evidence of a subterranean channel beneath Birmingham. This isn't to say that no such river exists, of course, but ratter to say that the assertion of such a feature is no stronger than what might be speculated regarding most any south-eastern city.

But there's more to subterranean streams than the karstology.



Fact 2: Joe Mulhatton, Traveling Salesman

Joseph Mulhatton (1851-1913) was a traveling salesman notorious for his farfetched tales reported as news. Newspaper editors surely recognized Mulhatton's stories to be fabrications, but in the spirit of one-upsmanship journalism, they printed them anyway, and in so doing spread the hoaxes across the nation.

Mulhatton described his creations as “novelistic journalism." In a December 1900 article, the Syracuse Sunday Herald, stated of Mulhatton, “He never made a cent by his lies and in ordinary business affairs he spoke the truth, but he had a mania for giving misinformation to the newspaper and indulged himself in the mania to the injury of his other business.”

By the beginning of the 20th century, "to lie like a Mulhatton" was a common expression for a preposterous tale.

Stories by or attributed to Mulhatton include:

George Washington Petrified (1877) Upon opening Washington’s tomb for repairs, it was discovered that the former President's body had been petrified, “the features perfectly natural, with the exception of eyes and ears, no trace of which can be seen. The body is of a dark leathery color, and may be said to be soft sandstone, which would likely break should an attempt be made to remove it from the sarcophagus.”	Grand Crystal Cave (1878) A giant Kentucky cave surpassing the grandeur of Mammoth has been explored for a distance of 23 miles. Mummified remains, similar to those found in Egypt have been discovered reposing in stone coffins. A local entrepreneur has intention of offering steamboat rides on one of the three underground rivers.
Carried Away by Balloons (April Fools Day, 1880) A Galveston lady bought a bundle of toy balloons from an Italian peddler and tied them to her child's wrist, upon which a sudden gust of wind carried the innocent aloft. The child would have been carried over the water if a skilled marksman who happened to be present hadn’t shot the balloons one at a time.	Texas Meteor (1883) A giant meteor has killed several head of cattle and completely destroyed the home of a Mexican herdsman, Martinez Garcia. Afterward, "the air was filled with sulphurous gas." The meteor, still hot and steaming, imbedded 200 feet deep in the earth and towering 70 feet above ground resembles the Court House at Fort Worth.
Star of Bethlehem Discovered (1887) Professor Klein has sighted the star of Bethlehem. As the star appears once in 300 years, astronomers had been looking for it for some time.	Monkeys Pick Hemp (1887) J.B. Parkes, a local farmer, has trained monkeys to pick hemp. If other farmers imitate his example, honest laborers will be put out of work.

North Carolina Breathing Cave A strong air current is emitted with a loud roar from a cave for several hours of each day. When the outward current ceases, the air rushes back with a roar equally as loud. People in the neighborhood believe that the earth is a huge animal and the cave is the mouth. Mulhatton seems to be rehashing a viewpoint of Aristotle. Chapter 47, Wrecks of Ancient Life, noted a similar breathing cave reported in 1910, the cause attributed to a subterranean stream.	Magnetic Saguaro Cactus In the Arizona desert grow two kinds of cacti -- those positively charged by the copper in the soil and those negatively charged. Approaching too close to the positively charged variety, one is drawn into its prickly embrace. Negatively charged saguaros, on the other hand, will repel one's body, flinging it into a waiting, positive-charged counterpart.
Carload of Cats On a certain date a buyer was said to be arriving to purchase a carload of cats. Cats were brought from all directions, but when the purchaser failed to materialize, the owners were doomed to disappointment and the freight agent had to return an empty car, instead of one loaded with felines.	The Cave in Pike County. Rooms filled with magnificent jewels. Long halls lined with great blocks of virgin gold. Subterranean rivers rippling over beds of diamonds. It's Sinbad, Chapter 16, Underground Rivers in English Fiction

We'll slip in another underground river yarn, this one in Montana, to illustrate how Mulhatton became a standard for tall-tale spinning. "Unlicensed Mendacity" from the Daily Yellowstone Journal, May 17, 1891,

> *The Glendive Independent promulgates in its last issue a yarn that dwarfs the most robust productions of the fertile brain of Mulhatton. It is about a mysterious circular basin hidden away in the buttes a few miles from Glendive, containing a lake, a river, and abounding with all sort of game, including buffalo. Caves in the cliffs indicate former occupation by man, and broken pillars and other remnants of pre-historic architecture show the dwellers to have been highly accomplished in the mechanical arts.*
>
> *The river having reached the end of the valley or basin, takes a short cut through the mountain, and this route the discoverers -- who are insufficiently described as "two gentlemen of Glendive" -- determined to pursue. Taking possession of a raft which they found handy, they entered the underground course of the river and after a time -- how long is not stated -- emerged into plain every day Dawson County sailing on what is known as Beaver Creek and fetching up at* Mingesville [Wibaux]*, from where they returned to Glendive. "The gentlemen" propose if possible to again find the entrance to this wonderful locality and explore it more minutely.*

The terrain between Glendive and Wibaux suggests how mysterious must be such a valley for it to have remained hidden from human eye.

The Montana account reduces to much the same plot as that of any number of fictional works we encountered in Chapters 16-25, except, of course, this one made the newspapers.

In the scope of falsifications, the Atlanta Daily Constitution, March 30, 1880, caught Mulhatton red-handed.

> *The report of the discovery of oil in or near Birmingham is entirely unfounded. Mr. Mulhatton, who sent the statement, is altogether too sudden and sanguine as a news gatherer. There are no signs of oil, or any prospect of an oil well.*

If a small lie fails, perhaps thought Mulhatton, try a bigger one.

Mulhatton's 1884 report of Birmingham Alabama's failing stone crust, to which we will devote more attention, drew national attention, but first, let us note that the period's interest in waters below the metropolis. Mulhatton was astute at striking where the iron was hot, and by 1884, the topic of a subterranean stream beneath Birmingham was on people's minds.

In 1871, R.H.L. Wharton purchased the "water privilege" for the city and dug wells on 2nd Avenue at 20th and between 20th and 21st Streets. The latter well was reported to have struck an underground stream and to be inexhaustible. Wharton's wells were closed after the establishment of the Birmingham Water Works in 1872.
In 1881, the area near 18th Street and 5th Avenue attracted a "large number of new settlers around the big spring."
In 1883, it was reported that men engaged in boring an artesian well in the city struck what seemed to be a small flowing stream of water at a depth of 100 meters.
An office in the vicinity of 5th Avenue and 22nd Street advertised "Mystic Underground River" excursions during the 1880s

”Birmingham's Wonder: The Curiosities of an Underground Stream -- How It Was Discovered," Atlanta Constitution, August 17, 1884,

> *While Atlanta is anxiously awaiting the slow descent of the dismal drill into the archaean rocks upon which she rests, with the fond hope than from these rocks there will gush forth 'ere long streams of limpid water, her young sister city has made a discovery that promises to be of incalculable benefit. This important discovery being nothing less than the finding of a bold subterranean stream of pure water passing from one end of the city to the other, and supposed to be about fifty feet under ground.*
>
> *How It Was Discovered. During a hard rain a few days ago it was observed that the water flowing along the large open sewer on Fifth Avenue suddenly disappeared at a certain point. Investigation showed that it was flowing into a newly made aperture in the bottom of the sewer. This aperture at first seemed but an insignificant hole, but upon peering down into it one could see that the water was dashing down into a large dark cavern.*
>
> *Thursday under the direction of Mayor Lane, two strong men with ropes tied around their waists descended into the cavern forty feet. They did not go down perpendicularly but took a stopping direction, stepping from crag to crag, following the dip of the huge limestone rocks. In a short while after they had gone down the signaled their comrades on the surface to draw them up. Upon reaching daylight the men stated that they did not get to the bottom, but heard what sounded like a large stream of water rushing along beneath them.*
>
> *A Lime Sink Known Years Ago. Some of the old citizens in this section before Birmingham came into existence... say this stream was known to them years and years ago; that farm hands were accustomed to going to a "lime sink" about where Fifth Avenue and Twentieth Street intersect, and attaching a plough-line to a small tin bucket, would lower this vessel into a small aperture, and then drawing it up would quench his thirst with the cool refreshing draught.*

As reported in the Birmingham Iron Age, August 21, 1884,

> *Hands are busy at work opening up the inlets to the underground river. One of the openings is on Fifth Avenue behind Twenty-second and Twenty-third Streets, the other in East Park, near the public school building.*

In the same issue, "The Subterranean Stream,"

> *Exploration Made for Thirty Feet -- Water Not Found, but Thought to be Heard.*
>
> *Mr. Lacy, boss of the street gang, and a Negro man made an exploration a few days ago for the subterranean river. They went under the ground from the big sewer, through a hole in its side in front of a tenement house on Fifth Avenue between Twenty-first and Twenty-second Streets. Stepping from ledge to ledge, with ropes around their waists, they descended about thirty feet, but their heads began to ache from the impure air that they returned. They first reached down for water, however, with poles about nine feet long, but as they didn't touch bottom they were little the wiser for their trouble, though both thought they could hear a stream.*

Local News. The same issue of the Birmingham Iron Age noted another advantage of such a stream.

> *Mayor Lane says he intends to have investigations made until the question of the existence of a good-sized stream is settled one way or the other. Even though it couldn't be made a water supply for the city, he explained, it could be made a valuable draining duet.*

Regional News. As reported by the Atlanta Constitution, August 28, 1884,

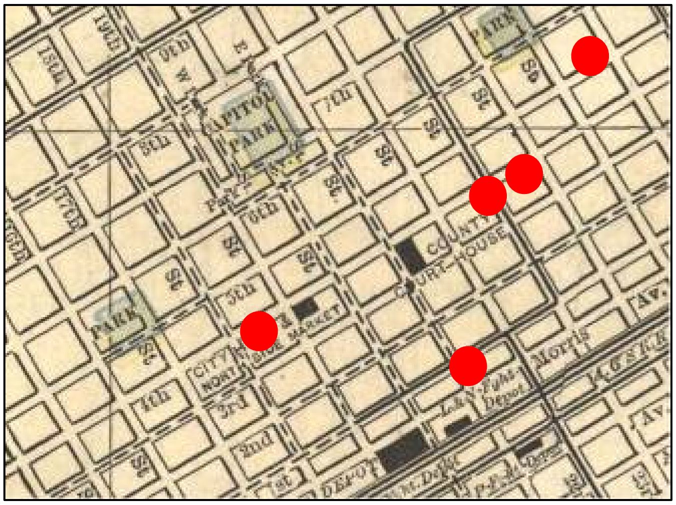
> *Birmingham, Ala. The underground stream is still the topic of conversation. It is about settled that it can be utilized as a main sewer.*

National News. "News Notes," Saturday Evening Post, November 29, 1884, contained the following.

> *An underground stream flows beneath the city of Birmingham, Ala. It is said to be used for a sewer.*

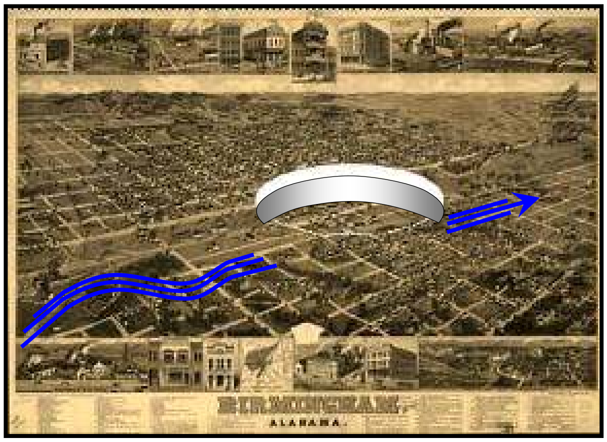
Unlike the Bellevue, Ohio scheme described in Chapter 75, Mainlining the Sewage," however, this particular possibility never came to be.

We've noted the locations on an 1892 map. The location of Birmingham's underground river seems well pinpointed.



Mulhatton expanded the artesian well news item into a headline-grabbing account of a subterranean river endangering the entire city. In excavation for large building, according to the report, the stone crust bridging Birmingham's underground river had been pierced and was now giving way. Buildings were collapsing and a corner of the City Hall had settled a meter into a fissure which was yet widening. Soon the entire structure, along with much of the downtown area, would disappear.

We've doctored a period sketch of Birmingham to indicate the consequence of the fabricated disaster.



Mulhatton sent his story to the Louisville Courier-Journal -- Birmingham readers would know that their City Hall wasn't collapsing -- from where it was relayed by newspapers across America. Birmingham was flooded with telegrams requesting details.

While Joe Mulhatton made no money from the yarn, others saw opportunity. "The Water Under the Earth: An Exaggerated Idea Prevalent Concerning Birmingham's Subterranean Stream," Atlanta Constitution; October 12, 1884, cites one such case.

> *Birmingham, Ala. Inquiries from all sections of the United States are being made relative to the stream that is supposed to beneath this city, and it is very evident that an erroneous impression with regard to the size of the stream prevails throughout the country, produced, no doubt, by articles apparently written in a spirit of Joe Mullatonism. A shrewd Selma negro took advantage of the exaggerated idea and got up the biggest excursion of the season in Birmingham. He advertised that a boat plying the subterranean river would give a free ride to the excursionists. They came by the train load, and spent the hottest day of the year vainly endeavoring to find the hole that led to the boat landing.*
>
> *The negro who got up the excursions has not returned to Selma.*

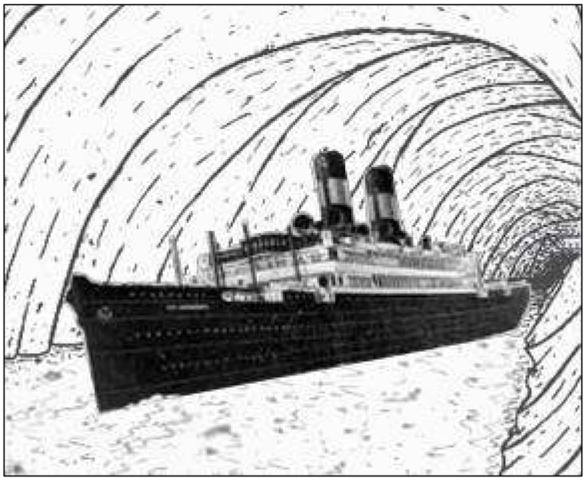
Pleased with the hoax, Mulhatton followed up with "Underneath Us." That this story first appeared in the Birmingham Iron Age, August 28, 1884, attests to Mulhatton's skill at keeping his story close to the believable.

"Underneath Us" is prefaced with "To the Age," as if from a commissioned correspondent. That the story's main character is one "Prof. Joseph Mulhatton" makes the joke all the more ludicrous.

> *The discovery of a great subterranean river under Birmingham has been the great topic of conversation the past week. Great excitement has prevailed, and so great was the interest taken in it that Dr. Jos. R. Smith, W.S. Brown, Wm. Hood, T.J. Brown, T.J. Brown, Wm. Burney, Geo. C. Kelly, J.B Earle, and other leading citizens held a meeting at which it was decided to telegraph Prof. Joseph Mulhatton, the great Kentucky scientist and cave expert in the facts of the case and urge him to come at once and make a thorough exploration. The result was that Prof. Mulhatton arrived from Louisville on Friday evening, and spent all day Saturday exploring the great subterranean wonder. A strong boat was quickly improvised in the cave from lumber which was lowered through the narrow inlet and the party proceeded down the river for at least fifteen miles before there was any obstruction to prevent them from going forward, and then it was a narrow formation of recent origin that can easily be cleared away. The natural tunnel through which the river flows is almost uniform width, and say about 300 feet for the distance of the fifteen miles navigated, and for height is at least 150 feet, so that a steamship of the largest class could navigate it with ease; the depth of the stream varies from 45 to 70 feet. It is connected with tide water, and this will give Birmingham a wonderful and cheap direct outlet to the sea, for the products of it furnaces, its mines and industries generally.*

We cited Horace Mann's 1851 suggestion of a Mammoth Cave underground steamship in Chapter 50, Then, Madam, You Should Go and See the Great Cave in Kentucky.

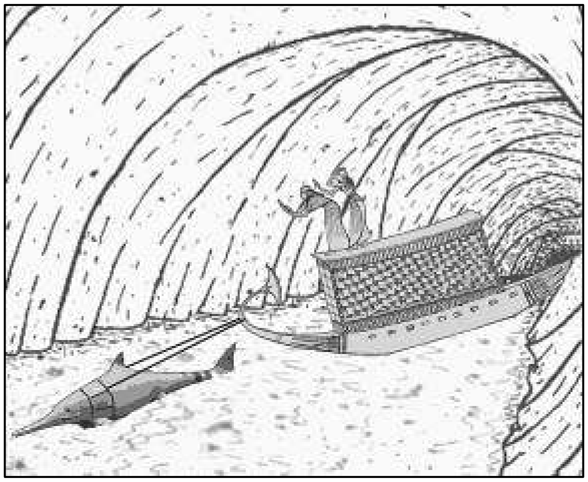
To the right is our rendition of Mulhatton's vessel which we'll dub one of the Birmingham-Gulf Steamship Line.



The above is Mr. Mulhatton's first impression of the wonder, which is fully corroborated by all of his party of daring explorers. But this is not all; Prof. Mulhatton has this to say of it: "The great subterranean stream recently discovered under the city of Birmingham is undoubtedly the most remarkable discovery ever made on the American continent. The river is greater in volume than the mighty Mississippi. Its vast subterranean bed is undoubtedly due to the grinding and cutting of immense icebergs during the glacial period. Then at a subsequent preadamite period violent upheavals of the earth toppled over the mountains which forms the present grand archway through which the iceberg continued to cut leaving it as it now -- a natural ship canal to the Gulf of Mexico. A prehistoric race undoubtedly utilized it for the transportation of metals from this section to the sea where they were transported to various points of then world. Furnaces on a scale scarcely so magnificent yet as satisfactory in results to those prehistoric people undoubtedly existed on the present site of Birmingham, as ruins of those, and of ancient sun-temples are found in various parts of the country."

"Added to this," says Professor Mulhatton, "we discovered in niches of the cave numerous articles of bronze, also statuary, numerous Masonic emblems, and mummies with sandals on their feet -- all in a perfect state of preservation. We also discovered the remains of marine monsters on the dais or old red sandstone period, prominent among them the huge ICHTHYOSAURUS, which was undoubtedly used by these prehistoric races to drag their ships from what is now Birmingham to the Gulf of Mexico. These extinct sea monsters were docile and harmless, and were harnessed to the ships laden with pig iron, which they pulled to the sea with the greatest of ease. They were more powerful than the most powerful locomotives of the present day. Hulls of these subterranean ships are scattered all along the banks of this great subterranean stream."

Assuming Mulhatton's ancient Birmingham civilization to be somewhat Egyptian-like, here's an idea of how the ichthyosaurus might have been harnessed.



> *Further explorations will be made today by Prof. Mulhatton and his scientific party, and the next reports will be eagerly looked for by the readers of the* Age *as the wildest excitement now prevails over these latest developments. Thousands of people have been crowding around the entrance to the river clamoring for admission. Prof. Mulhatton saw numerous eyeless fish and eyeless sea-monsters of the shark species; also eyeless amphibian animals of the alligator and reptile tribe. He says a company should be formed at once to clear the river of any obstructions, and that boats and barges to navigate it should be constructed at once. As the entrance to it is on one of the streets of the city, it will therefore belong to the city and cannot be claimed by any private individuals.*

"An Underground Wonder" in the Birmingham Iron Age, September 25, 1884, illustrates the public reaction.

> *A Greenville N.C. Gentleman Wants to Know About the Mystic River*
>
> *The following letter has been received by a citizen of Birmingham:*
>
> *Dear Ed.: Last night I read an article copied from the* Birmingham Age*, which gives an account of the discovery of a wonderful subterraneous river at Birmingham. There are some things in the article that sound like the truth, but there are others that sound like the work of a vivid imagination. I am very anxious to know the "whole truth and nothing but the truth." For this I write to you. Your friend, Z.D.M.*

Mulhatton would have been doubly pleased, as a well-tempered hoax snares the gullible, while at the same time, leaves the victim scratching his or her head.

Local lore of a subterranean stream was enhanced by "A Voyage on the Underground Stream," Birmingham Iron Age, June 3, 1886, written by "H," possibly "Mulhatton" sans first syllable, but more likely someone simply lying like a Mulhatton.

> *The fact that there is a large stream flowing under this city is well known, but the writer and a companion are doubtless the first voyagers upon this mysterious stream.*
>
> *Sunday afternoon my friend George and myself went to Avondale for the purpose of exploring the cave. We carried a lantern, and by the aid of its light we penetrated to what was apparently the end of the cave, where we paused to rest a moment before returning. While seated on the rocks, we both distinctly heard the sound of running water.*
>
> *"Let us see what it means," said George, pulling away a large boulder from a small opening through which the sound seemed to come. When the stone was removed it left an opening large enough for a man to crawl through, and just beyond this opening we discovered a stream of clear, flowing water, about thirty feet in width and apparently about five feet in depth. The*

bed of the stream seemed to have been tunneled through solid rock, and there was an open space six to eight feet above the water.

"Let us get a boat and take a ride on this creek," said George... We at once decided to do so and strolled around the park until night fall, when, after considerable difficulty and hard work we succeeded in getting a boat from the lake to the cave and finally launched it upon the underground stream.

"Farewell, vain world," exclaimed George, as we pushed out into the stream and began to row against the current... Talk about Egyptian darkness! Why it could have been a brilliant light in that place.

Rowing steadily up the stream for about half an hour we were brought to a halt by the stream branching in half a dozen different directions. Turning our boat around we let id drift downstream with the current which seemed to be flowing about four or five miles an hour. George and I were both satisfied with our voyage and intended to return through the cave the way we came, but we failed to discover the opening by witch we entered, and after an hour we were forced to admit that we were adrift underground.

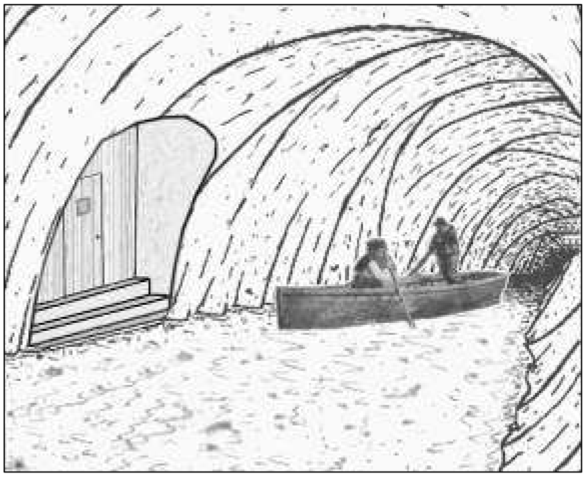
We saw there was nothing to do but drift with the current and trust to luck. We surmised from the course of the stream that we would pass directly underneath the city and the heavy rumbling of passing trains which we could distinctly hear directly overhead, assured us that we were beneath the railroads.

Gazing in silence at the wall of darkness around us, horrible little goblins with wild eyes would glare at us of a moment and then fade into the darkness from whence they came.

When we were probably two miles below the city we discovered just ahead of us a small light which flashed dim and weird in the gloom. As we came nearer to the light we could distinguish the sound of voices and the regular clanging of a small printing press. "What can this mean?" whispered George, as our boat came close to the light and we discovered it came from a small opening in the wall. With a slight dip of the oars I brought the boat directly beneath the mysterious light, and there we found a small boat anchored and steps leading from the water's edge up to what appeared to be the entrance to an underground chamber.

Securing our boat, we climbed silently up the rude steps until we could see into the mysterious room from which came the noise and light. The sight we beheld made our blood run cold for a moment. Beyond the opening was a rock-walled room about 12x12 feet containing a few articled of furniture and a small job printing press. Reclining upon a small lounge at the far end of the room was a beautiful young woman who seemed to be asleep. Seated at a small table was a dark featured man who seemed to be engraving, a negro was running the press and turning our twenty dollar bills at a very rapid rate, while at his side, apparently the ruling spirit of the place, stood the notorious and escaped convict, Steve Renfro. We had found a counterfeiters den, there was no mistaking that, but the only satisfaction afforded us by the discovery was the assurance that there was a way out of the horrible place in which we were.

Here we insert another graphic, this one showing "H" at the stern and his companion George at the bow approaching the lair of the notorious Steve Renfro and his counterfeiting gang.



We'll jump ahead to where the boaters make their escape and fall asleep in their drifting craft.

> *Our first thought upon awakening was, is this not some sort of horrid dream? But the hoarse murmur of the now swiftly flowing stream and the wall of darkness around us proved a stern and fearful reality.*
>
> *The current of the stream was growing swifter with every mile massed and by 12 o'clock we seemed to be going at a rate of ten miles an hour.*
>
> *About four o'clock we saw what appeared to be a star in the distance which kept growing larger and larger as we sped on through the gloom, and in half an hour from the time we first saw the light our boat shot out of the darkness upon the Warrior River.*

It's hard to suppress a popular concept, it seems, as illustrated in "Underground Streams: Birmingham as Rich in Water as She is in Coal," Atlanta Constitution, March 25, 1886.

> *Much excitement exists over the report made today by W.C. Kerr, who is boring artesian wells for the water supply of the Birmingham rolling mills. Two holes have been bored a depth of five hundred feet beneath the surface. Water, pure and clear, filled the wells within twelve feet of the top. It was announced by Mr. Kerr that the water came from an underground stream, the size of a village creek, on which is built the city water works. The stream is large enough in places for boats. Persons placed their ears to the top of the hole, and heard the water rushing below.*

The topic of underground rivers encompasses the spectrum of truth and falsity; to swear by the Styx (Chapter 63) has long been a guarantee of utmost voracity, yet at the same time, tales of underground rivers have been renowned hoaxes.

The Verdict

It's but geologic speculation if Birmingham, Alabama sits above an underground river. There's no data supporting the assertion, but karst can be elusive. Not much of a story, here.

In terms of fiction, however, the city's underground river is well established. Mulhattons will long be told. As our journey has made us well aware, underground rivers are about so much more than geology.

Let us thus end our Birmingham visit with some poetry.

The August 21, 1884, Birmingham Iron Age shouldered the mantle of civic leadership and named the subterranean stream

> *The Age has assumed the responsibility of naming Birmingham's underground stream. It shall be called the "Mystic River." This name is not only a fit appellation of the wonderful unknown waters, but has a poetical ring about it which will prove of much value to aspiring poets and poetesses to illustrate.*

The Age then illustrates for us the poetic ring.

We'll idly float
In fairy boat
Where moonbeams never quiver.
Well pull an oar
To foreign shore
Down on the Mystic River

That's just the first of first of several verses, but suffice to note the poetic potential.

We'll leave the underground river in Alabama with another poem about Birmingham, the wrong Birmingham, we realize, but the British city is also an inland industrial metropolis with its own traditions of disappeared waters. As with the lost rivers of London, Chapter 73, The Sinking of the Fleet, however, the lore from England tends to stem from sounder history. We quote "Birmingham River" by Roy Fisher from The Long and the Short of It: Poems (2005).

Where's Birmingham River? Sunk.

Skipping a few lines,

Caught on the right shoulder
by the wash that's run under Birmingham,
a slow, pretty river with no memory of an ancient name

And ending,

Sank out of sight under streets, highways, the blank walls of workshops;
collected metals, chemicals, aquicides. Ceased
to draw lines that weren't cancelled or unwanted; became
drains, with no part in anybody's plan.

Offered the choice of dreary British despondency or a boldly-penned Alabama hoax, we'd rather mull the underground river of Mulhatton.

We'll end the chapter with another underground river newspaper hoax, but this one not by Mulhatton.

ROCKY MOUNTAIN
THE NEWS

As chronicled in Robert L. Perkin's The First Hundred Years: An Informal History of Denver and the Rocky Mountain News (1959) with a citation to "Early Day Reminiscences of Col. T.C. Dickson," The Trail VII:7, December 1914,

Some of the early Denver bunco schemes were scarcely less imaginative than the tall tales and hoaxes which delighted nineteenth-century newspapers, including the Rocky Mountain News. Joseph E. Hood, who became an associate editor of the News, whipped up one which was republished throughout the country as a fabulous advance in geologic and geographic knowledge. Hood had been with Samuel Bowies' Springfield, Massachusetts, Republican before he came west with his Jules Verne fantasies.

With a perfectly straight face he told of an interview with a man who had made an underground voyage from the Great Salt Lake to southern Colorado. Salt Lake, he pointed out, has no known outlet. In southern Colorado there was a lake with no known inlet. The mystery of how this could be now was solved. Hood's voyager had been boating on Salt Lake and was caught in a whirlpool which bore him straight downward into the earth to a great underground river flowing in a tunnel-like cavern hung with varicolored stalactites of great beauty. The man's boat was whipped along this nether-world river for a distance of something over six hundred miles at breath-taking speed. Finally he shot upward and popped out on the surface of the Colorado

> *lake. Hood, by virtue of the great and cost-scorning enterprise of the News, had obtained an exclusive interview.*
>
> *S.T. Sopris, late night telegraph editor for the paper, said Hood's story was copied from the News by many papers, East and West, and a goodly number of people swallowed it whole. It was the sensation of the day.*

While the Great Salt Lake outlet to southern Colorado seems not to exist, we still have the reputed subterranean outlet to the Pacific revealed in Chapter 86, The Rio San Buenaventura.

CHAPTER 81

EAST SIDE, WEST SIDE, ALL AROUND THE TOWN

We include in this chapter several items which could have been thematically placed in previous chapters, but together relate to a particular location, New York City. We'll take some liberty with the chapter's title, however, and cross both the Hudson and East Rivers as needed.

Here are a few of the City's underground rivers.

The New York City Aqueducts

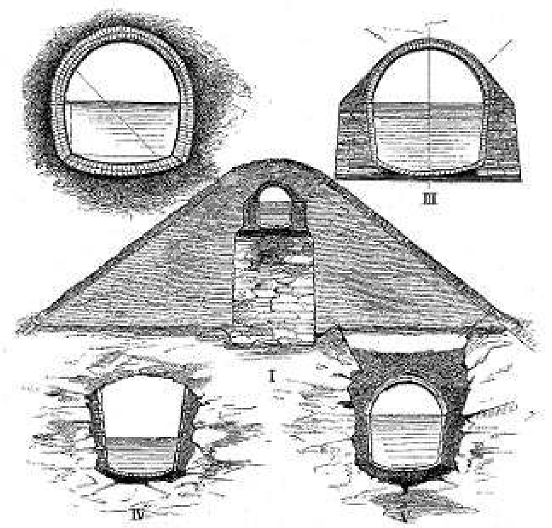
Eight million residents of New York City, and another one million upriver, daily consume 4 to 5 million cubic meters of water that flow through a network of reservoirs and aqueducts stretching from the Delaware River watershed to the Connecticut border.

The Croton system in Westchester County, which began providing water in 1842, meets about 10 percent of the city's needs.

The Catskill system, "City Tunnel Number 2," built in the first quarter of the 20th century, provides 40 percent.

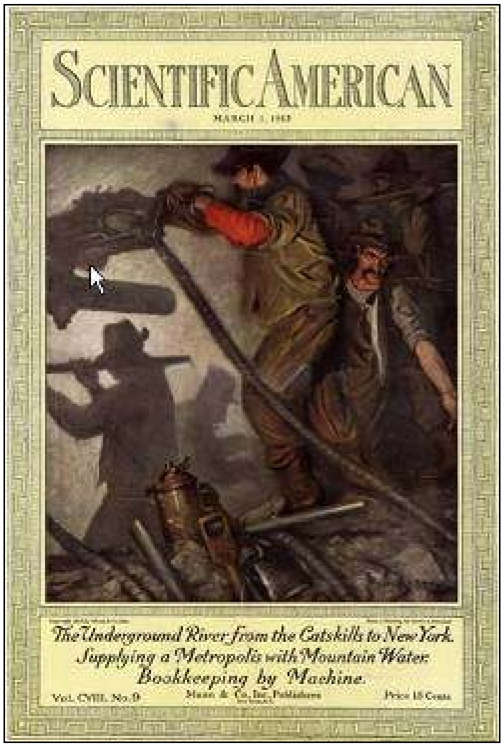
The remaining 50 percent also come from the Catskills, but through the Delaware Aqueduct, completed in 1945.

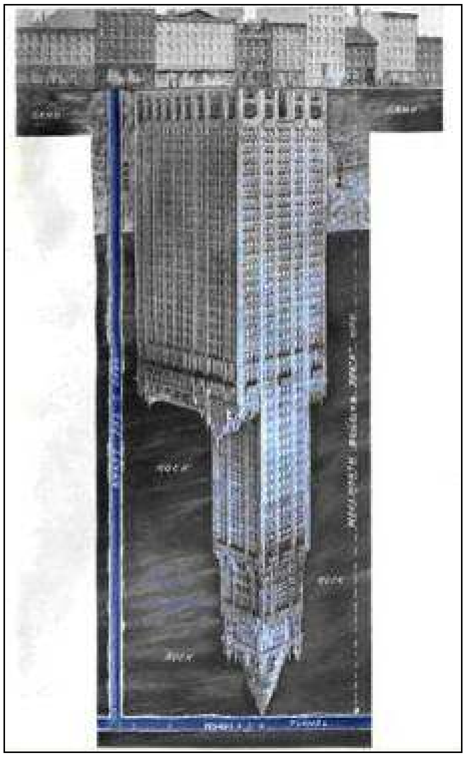
The Croton Aqueduct was a large and complex water distribution system constructed between 1837 and 1842 to transmit water by gravity from the Croton River in Westchester County 66 kilometers into reservoirs in Manhattan. The cross-sections to the right are illustrations from Harper's Magazine, December 1860.



SECTIONS OF THE AQUEDUCT, SHOWING ITS CONSTRUCTION.

To the left below, the March 1913 Scientific American lead story, "Underground Rivers...," chronicles the progress of New York City's 100-kilometer 5-meter diameter underground aqueduct to the Kensico Reservoir near White Plains.


SCIENTIFIC AMERICAN
MARCH 1, 1913
The Underground River from the Catskills to New York.
Supplying a Metropolis with Mountain Water.
Bookkeeping by Machine.
Vol. CVIII. No. 9
Munn & Co., Inc., Publishers
Price 15 Cents


SAND
SAND
ROCK
ROCK
ROCK
TUNNEL

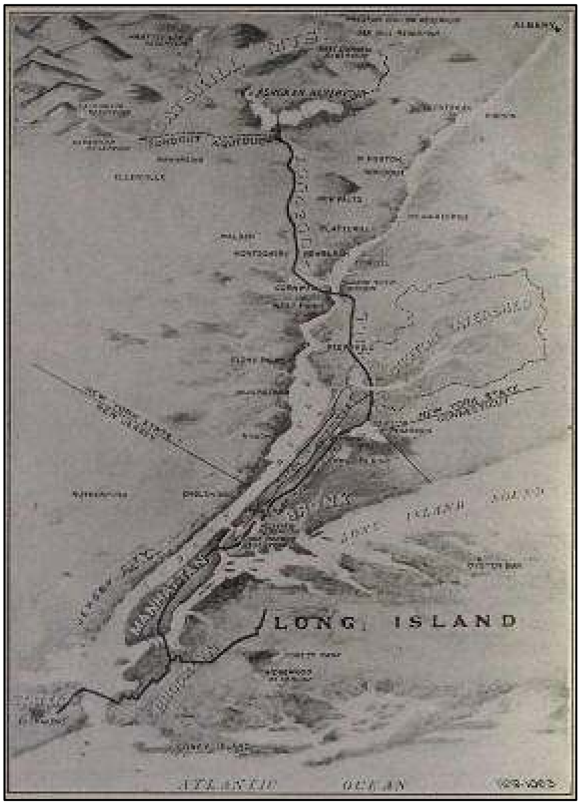
Above to the right, the authors J. Bernard Walker and A. Russell Bond of Creating a Subterranean River and Supplying a Metropolis with Mountain Water (1914) invert a Woolworth Building illustration to comparatively demonstrate the "Subterranean River's" depth. We've highlight the excavation in blue.

The project's objective,

> *To conduct the Catskill water into Brooklyn and Queens, it was decided to build... a course for a subterranean river which could be tapped as needed for the city's supply, and which at the same time would be so completely buried that it would never menace the safety of structures above it.*

The author's subsequently clarify, however, that it's actually not a "river."

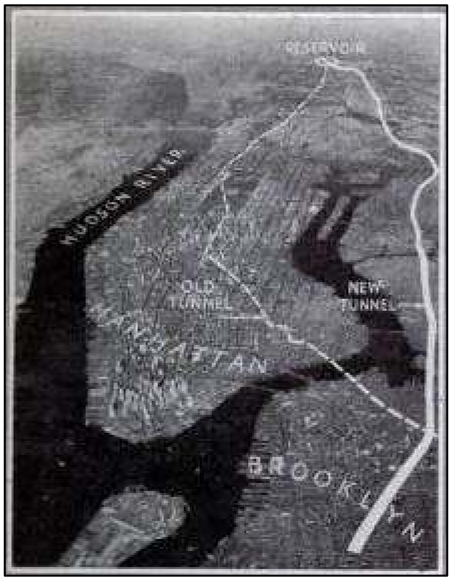
> *The system under construction and now nearing completion consists of a large reservoir in the Esopus Basin, an underground aqueduct 17 feet in diameter by which the water is led for 64 miles to another large basin, the Kensico Reservoir*



The map to the right is from The Catskill Aqueduct and Earlier Water Supplies of the City of New York with Elementary Chapters on the Source and Uses of Water and the Building of Aqueducts and an Outline for an Allegorical Pageant (1917) by the Mayor's Catskill Aqueduct Celebration Committee.

As for the allegories,

> *The first symbolizes the gift of water for food production, at the same time typifying the manner in which Nature gives water to man.*
>
> *The second symbolizes the gift of water for drink, and the curse of drunkenness.*
>
> *The third represents the gift of water for health; in this are included the general ideas of personal cleanliness, domestic hygiene and public sanitation.*
>
> *The fourth represents the use of water for fire extinguishment.*
>
> *And the fifth typifies the use of water for power, its use in the industries, and its function in bearing commerce.*



New York City was yet building underground rivers in the 1930s, as excerpted from "World's Largest Water Tunnel" in the December Popular Science.

> *Far beneath the feet of tramping millions, the longest tunnel of its kind in the world is nearing completion in New York City. Twenty miles in length, it will help distribute a billion gallons of water a day to New York homes and factories. Officially, the shaft will be known as City Tunnel Number Two.*
>
> *City Tunnel Number One, completed fifteen years ago, has long been overtaxed. Hence 2,500 workmen have been toiling day and night for the last three years to construct the supplementary tunnel. To cut it through solid rock, they exploded 8,000,000 pounds of dynamite... A railroad train could be driven through the new fourteen-foot shaft.*

Now abandoned -- except by tree roots -- the Old Croton, shown her beneath the Bronx.

We'll not delve into the Delaware Aqueduct because we fear becoming sucked into the leak mention Chapter 46, Finding the Underground Rivers.

Now the nation's glory days of infrastructure construction have passed and time takes its toll. According to the Environmental Protection Agency, 240,000 water main breaks occur each year in the United States. Those living in New York City are instructed to call 311 if they see one.

East Side

To the east lies Long Island, bedroom to Manhattan commuters, and the abundance of Long Island groundwater has long been a topic of popular discussion.

"From Subterranean Streams, Capacity of the Jamaica Water Works to be Largely Increased with Another Plant at Richmond Hill," Brooklyn Eagle; August 22, 1899, notes the resource.

> *President Charles Lockwood of the Jamaica Water Supply Company... offered to supply the city* [of New York] *at 50 cents or less per thousand gallons, and the entire supply was to be obtained from the inexhaustible underground rivers of pure water which exist on Long Island...*
>
> *The large property owners who now object to the draining of the ponds and surface waters of Nassau and Queens say that they have no objection to the tapping of the deep underground supply.*

But from where does this subterranean resource come?

In the memory of modern Golden Hill Native Americans of the Paugussett Nation is a lake in what's now downtown Bridgeport, Connecticut fed by what was said to be an underground river flowing 60 kilometers from the north.

Or is this underground river even longer?

To explain a gruesome history of western Long Island drownings, the October 8, 1900, Lewiston Evening Journal noted,

> *There are several branches to the underground river, but that no one has ever found the spot where they emptied. It is known that there is a system through the sandy soil a hundred feet or more below the surface of Long Island. It is said that the main underground system, which is as wide as a small river, comes down from the White Mountains, dives down under the Sound somewhere near New London and upon reaching Long Island branches out into a system with subterraneous veins, reinforced by springs, ponds and lakes, that threads the entire undersoil of the island.*
>
> *The fact that the underground outlet of Secut, now Success Lake, has more than one branch would account for the bodies of a great many persons drowned in its waters never having been recovered.*

Lake Success today, where success is measured on the many golf courses

Three decades later, however, the question of Long Island's water source would seem to have been settled. As reported in "Relation of Geology to Ground Water Supplies of New England," Journal of the New England Water Works Association, March 1933,

> *It was once supposed that the water on Long Island came from Connecticut. More than twenty yeas ago a very extensive study of the groundwater conditions of Long Island was made by W.O. Crosby. His conclusions were that the water-bearing beds under Long Island are not continuous from under Connecticut. We do not have those coastal plain deposits exposed at all in Connecticut. They have been eroded, washed away from the Connecticut side of Long Island Sound, and the hard rocks, with a little veneer of glacial drift, are exposed right down to the Sound. The water-bearing beds which pass under Long Island probably come to the surface under the Sound unless they are controlled by impervious layers of clay. The groundwater of Long Island is entirely the water that falls as rain on Long Island. It is not possible to draw large supplies there from New England. It is possible that some of the water that might be found in the hard rocks on the western end of Long Island comes from the mainland, hut there is not sufficient evidence to be sure about that.*

On November 20, 1949, however, the Sunday Herald was still perpetuating the "underground river" concept.

> *Drought Doesn't Hurt Bethel's Water Supply. While the rest of Fairfield County's well-users suffer from the "underground drought" which has dried up their water supplies, the Town of Bethel steadily pumps 380 gallons-per-minute out of a mysterious subterranean source...*
>
> *Supt. of the Water Dept., Herbert A. Webb ... said that Bethel draws its water from a mysterious underground river, which geologists believe extends from Long Island beneath the Sound, into Bethel and finds its source in the hills of Litchfield...*
>
> *Intrigued, Webb and Selectman Thomas H. Mannion queried hydraulic engineers and geologists about the seemingly bottomless well.*
>
> *A check-up showed that only one other community in the East has water whose characteristics are the same as Bethel's.*
>
> *This area is on the Western tip of Long Island and the water is obtained from an underground river which geologists have traced beneath the Sound.*

And today?

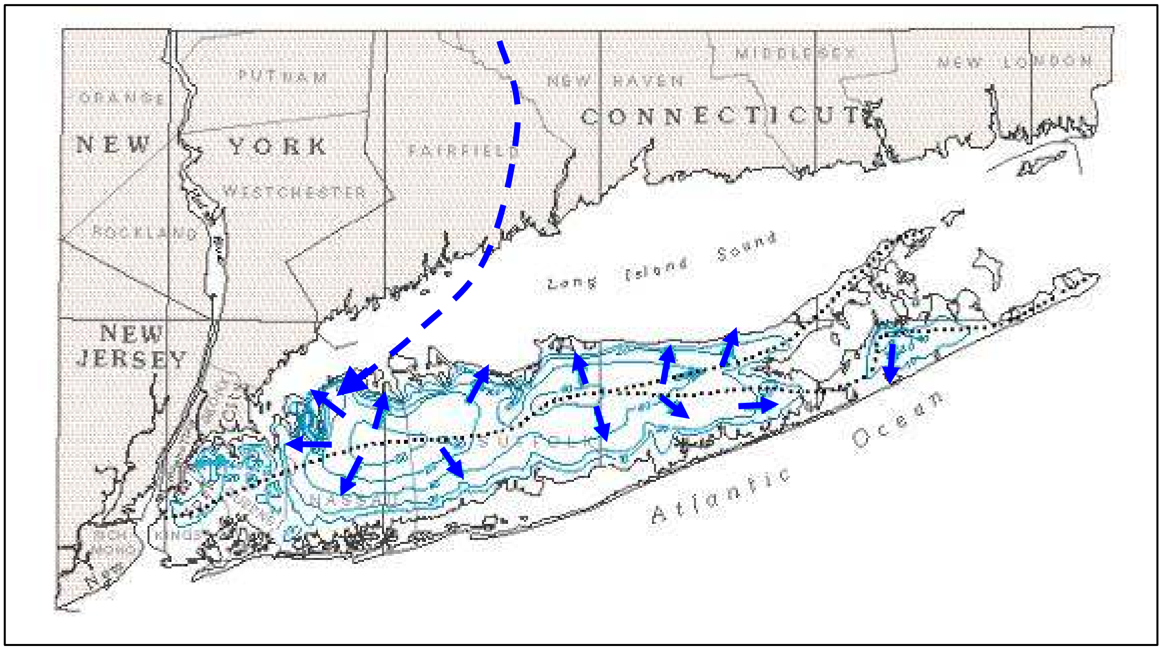
The waters yet resurface, but in the form of urban legend. From the New York Times, November 13, 2005,

> *Q: I once heard a story about a lake in Queens that people thought was practically bottomless. This sounds like a summer camp ghost story. Is it true?*

A: You must mean Oakland Lake, but the truth about it wouldn't scare a mouse. Oakland Lake, in Alley Pond Park south of Bayside, is a 15,000-year-old glacial kettle pond, formed by the melting of a large chunk of glacial ice, according to the Parks Department. The pond is fed by underground springs and a ravine, and the story was told that the pond was as deep as 600 feet, with an underground river leading northeast to Little Neck Bay. In 1969, amateur divers searched for the lake bottom, fearing dangerous currents from the suspected river. It turned out that Oakland Lake was about 20 feet deep, and there was no River Styx.

In 1988, the state declared that the lake area was officially freshwater wetlands; the marsh supports many birds, and some of the original forest remains.

The path of the perceived underwater, underground river is mapped below as the dashed line. The short, solid arrows, on the other hand, show the direction of Long-Island's groundwater gradient, how the groundwater actually flows. As the Long Island Sound stratigraphy is not particularly porous -- much less, a riverine submarine pathway -- the island's groundwater comes from local precipitation, not from under the Sound, a fact known before 1933. The submarine underground river no more than an imagined dashed line.

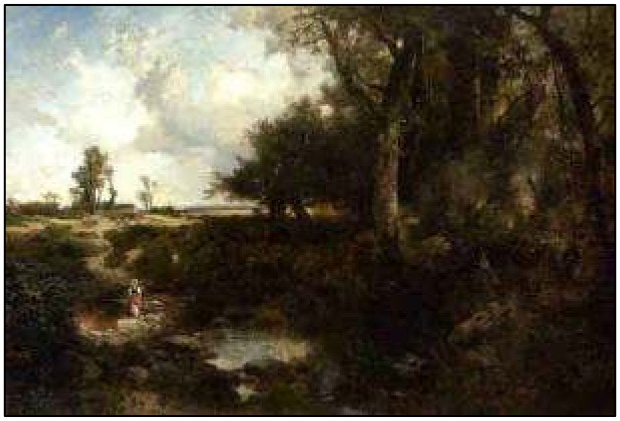


But the Long Island legend will surely rise again.

As for the dashed blue line, it's a tale we'll save for Chapter 83, Professor Denton's New England Underground River.

Alas we seem to have been on the path of a nonexistent underground river, but we can find solace in the fact that we weren't the first to do so.

West Side



To the west of 19th-century New York City lay land barely touched by urbanization.

"Crossing the Brook near Plainfield, New Jersey" by Thomas Moran (1837-1926), a painter of the American Hudson River School, reflects the influence of the American Pre-Raphaelites' fascination with the natural world.

But Moran's natural world was already making way for commuters. As reported by the March 14, 1892, New York Times, "An Underground River Flowing Rapidly Beneath the City of Plainfield, N.J.,"

> *The people of this city are greatly puzzled at the discoveries made by the Plainfield Water Supply Company, and the wonder of what sore of floating municipality they live in. For a week the company has been endeavoring, by crucial tests, to determine the exact magnitude of its water supply... Further investigation has established the fact that the wells actually tap a vast underground river flowing from northwest to southeast directly under the city, many feet below. Soundings have been taken, and other tests have been made, and it is now announced by competent engineers that a stream of extraordinary extent actually exists under the city. It has a swift current, and sweeps over a bed of beautifully white, smooth pebbles. The quality of the water is then purist and the supply is practically inexhaustible.*

The April 15 "An Extensive Water Service" reinforced the "underground river" perception.

> *The Union Water Company, an organization virtually the same as the Plainfield Water Supply Company, has completed arrangements for extending its mains to Cranford and Rosella. Ex-Congressman John Kean, Jr. is President of the company whose water supply is the inexhaustible wells which have been sunk at Netherwood, tapping an underground river.*

Remember that name, Ex-Congressman John Kean.

As pondered in "Under the Florida Sands, A Five-Acre Lot that Broke Through the Sands," the May 29, 1892, New York Times,

> *There is a mystery about the foundation of the Florida peninsula that none of the geologists has yet given a satisfactory explanation of,*

followed by a recounting of Floridian sinkhole and artesian springs tales. So why do we cite this news item in relation to the New York area? The answer's both Tartarussian and cigar-chomping politics.

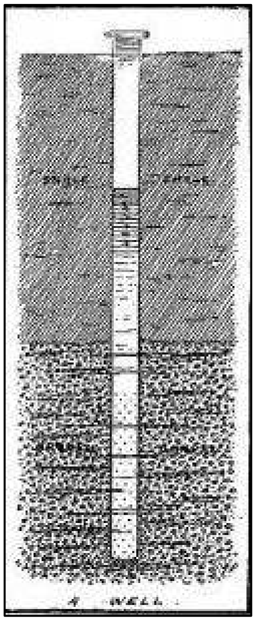
> *These things lead me to the sage conclusion that there is an immense hollow in the rocks that underlie the Florida peninsula, a great cavern by the side of which Luray and Mammoth Cave are toys. A cavern with rivers running through it, one of those rivers having an outlet in the fresh-water spring near St. Augustine and another in the Silver Spring. Where these underground rivers rise I am not yet prepared to say -- perhaps New Jersey -- for I see that the Hon. John Kean, Jr. discovered a river of pure water under Plainfield two days before he called the Republican State Committee together.*

This report falls into the interim between Kean's service in the House of Representatives ending in 1889 and his time in the Senate, beginning ten years later. We question the Hon. John Kean being the "discoverer" of water beneath Plainfield, but then as now, politicians claim credit for good news.

As reported in "Plainfield, N.J., Water Supply," Scientific American, November 5, 1892,

> *An underground river, with the cleanest and purist of water, has been discovered near the city of Plainfield, N.J. A few months ago the water company began to drive wells, and, after going over about five square miles of country and striking inferior qualities of water they struck pure water at Netherwood... The earth thought which these wells are driven is a hard shale, running down to a depth of 27 ft. It is so compact that no drainage or surface water can get through it, and below it is a bed of sand and gravel, through which the pure and clear water flows. The wells run down to a depth of 20 ft. into this bed, the gravel which is smooth and polished, showing that the water is constantly moving.*

The article's illustration makes clear that the well doesn't encounter what might construed as a "river," but the lead sentence coupled with the reference to stream-polished gravel paints its own picture.



A WELL.

Other than the atmospheric reference, "A Great Natural Feature, The Explanation of Plainfield's Pure Water Supply," New York Times, January 8, 1893, described Plainfield's actual hydrology in terms far ahead of the times.

> *The abundant water supply is not caused by an underground river, as claimed by the Scientific American in a recent issue, but is received from superficial earth twenty-five to seventy-five feet deep, lying upon basement rock, consisting of loam, sand, and gravel, saturated its whole depth from about eighteen feet below the surface.*
>
> *The particular soil through which geologists call moraine or glacial drift, laced thousands of years ago, has been shown by recent experiments to be the best kind of a purifier. Through this compact mass there is no rushing river, as has been described, but only the steady movement of water among the interstices of consolidated sand and stones, which, being nature's perfect filter, gives Plainfield its pure water and healthy atmosphere.*

Such accurate journalism didn't persist, however. In promoting Plainfield real estate in its August 26, 1894, feature, "Plainfield, City of Homes, Attractive Features of the Old New-Jersey Town," the newspaper reverted to the time-honored "underground stream" illusion,

> *It was found that a current of water ran under the city from the near-by mountains, and dredging produced glistening pebbles, as from the bed of a stream.*

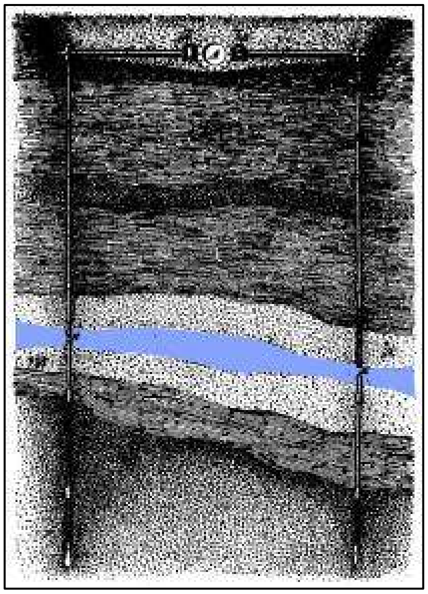
In an engineering document, Report on the Water Supply of Plainfield, New Jersey (1910), James Hillhouse Fuertes summarized his findings.

> *Source of Water -- Many suppositions have been made as to the probable source of the water found in the gravels and sands under the plains between the moraine and the mountains, the commonly expressed idea being that it is an underground river flowing in a southwesterly course towards the Raritan River having its headquarters at or near Springfield. While confirming the view that the general natural direction of the' movement of the groundwater is towards the southwest, as has been observed by the levels of the water in local wells, my observations lead me to the belief that the source of the water is purely local.*

Fuertes' conclusion:

> *The source from which the Netherwood wells derive their supply is local; and from 3 to 4 square miles in effective superficial area.*

In other words, there's no underground river.



Brooklyn

If A Tree Grows in Brooklyn, a 1943 novel by Betty Smith, perhaps it gets its water from a stream below. Such a stream has long been believed to exist.

The drawing to the right (the blue added to better show the perceived watercourse) is a Scientific American illustration of "underground water courses pierced by driven wells" from "City Water Supply from Driven Wells," February 12, 1887.

> *These underground waterways are generally not difficult to find in comparatively level country, and usually at a surprisingly slight distance below the surface. The manner in which these streams are frequently formed, one above another, at various depths is clearly indicated in one of our illustrations.*

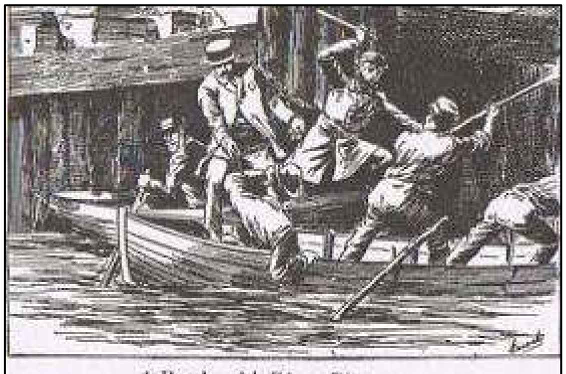
Ah, for the era of unbridled Yankee optimism.

From the New York Times; January 7, 1907;

> *Driving 200 Wells to Supply Brooklyn. Thorough Search Made for an Underground Stream... Chief Engineer McKay Skeptical. By means of a chain of deep driven wells, extending from a point near Jamaica eastward into Nassau County for a distance of about fifteen miles, the engineers of the Water Department in Brooklyn believe they will be able to determine within a short time whether there are streams flowing under Long Island big enough to supply Brooklyn for all time, and possibly furnish a large part of the water consumed in Manhattan.*

Chief Engineer McKay was correct.

We introduced the subject of subterranean stream piracy in Chapter 39, Karstology, but that was just about karst chemistry, the details already having faded from our minds. Most of us would find more interesting the topic of actual buccaneers who sail below.



A Battle with River Pirates

"The Atlantic Avenue Tunnel, A Romance," New York Times, January 23, 1893, told of a Brooklyn's vicious Smoky Hollow river pirate gang whose den opened into the abandoned 1844 railway tunnel.

Thomas Edison filmed a 2-minute simulated river-pirate capture by a New York Harbor Police boat in 1902.

The "river pirate" connection stuck, as seen in a 1911 issue of the Brooklyn Eagle.

The fact of the matter is that these river pirates didn't actually sail below Atlantic Avenue -- the tunnel being dry -- but launched from below the waterfront docks. None the less, their dastardly legacy's now part of the public association between "underground," "river" and "pirates."

Today's Big Apple is rife with underground rivers, but as demonstrated by Steve Duncan, "Urban Explorer," in his June 2008 web report on rediscovering the Manhattan waterways, exploration's not easy.

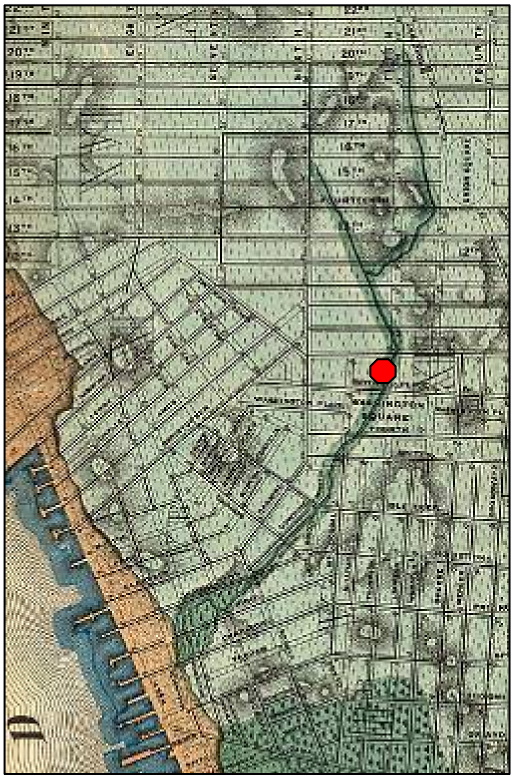
Minetta Brook

In New Amsterdam times, Minetta Brook was a placid Manhattan stream. By the 1800s, however, the brook was diverted beneath Washington Square the West Village. Today's Minetta Street in the Village bends to follow the stream's original path.

The brook's concealment wasn't an easy bit of engineering, however. As reported in the New York Times, March 27 1901,

> *Minetta Brook's Course. Imprisoned Underground, It Shows Itself in an Excavation for a Mammoth Store. Minetta Brook, once a placid stream dividing Manhattan Island from the North of the East River, is responding to the rains in a way that results in trouble for Thomas P. Galligan, who is digging in its Sixth Avenue channel... According to Mr. Galligan, Minetta Brook asserts itself still in wet weather in the sub-cellars of many big buildings.*

When Fifth Avenue was constructed just north of Washington Square, a tube was installed, allegedly connected to the old brook. Gen. Egbert L. Viele's "Sanitary & Topographical Map of the City and Island of New York" (1874) shows the original channel. The red circle identifies the site.



The stream map was reprinted in "Who Stole the Creek?" in the September 13, 1907, editon of the New-York Tribune with subheadlines "Manhattan's Famous Underground Stream Has Disappeared" and "The Northwesterly Bed of the Creek Cannot Be Found."

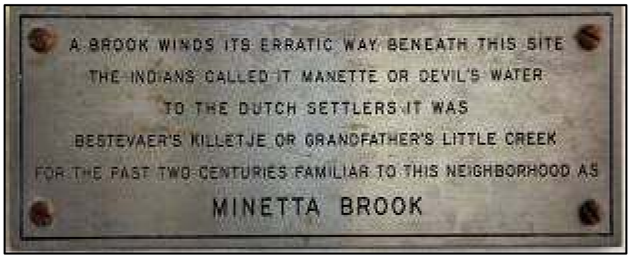
The 1874 mapping of Manhattan's historic watercourses is yet consulted for skyscraper foundation design.

From the New York Times, December 4, 1930,

> *Minetta Brook Out Again, But This Time Historic Old Stream Will Flow from Fountain... The waters of Minetta Brook, covered over time and time again in efforts to stem their flow, found*

> *their way to the surface again in the Washington Square section yesterday. However, this time the persistent stream was aided by pipes, designed to convey the water to a fountain built in the lobby of a new apartment building...*
>
> *The brook has not always waited for faucets to be turned. It has been the bane of builders in the Greenwich Village section for many years. A favorite trout stream in the Dutch Colonial days, Minetta Brook, or Minetta Water, as it was called then, still flows underground into the Hudson, fed by underground springs, as nearly as can be determined.*

The plaque beside the "fountain,"



A BROOK WINDS ITS ERRATIC WAY BENEATH THIS SITE
THE INDIANS CALLED IT MANETTE OR DEVIL'S WATER
TO THE DUTCH SETTLERS IT WAS
BESTEVAER'S KILLETJE OR GRANDFATHER'S LITTLE CREEK
FOR THE PAST TWO CENTURIES FAMILIAR TO THIS NEIGHBORHOOD AS
MINETTA BROOK

The connection to the subterranean stream may be more symbolic than hydraulic, as some say that the Minetta dried up in the 1800s and the water at the bottom of the pipe nothing but plumbing seepage, but it's in the tour guides.

Queens and the Bronx

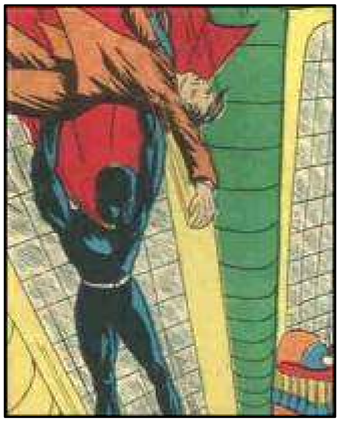
Sunswick Creek, Queens, appeared on maps in the 1870s, but is now completely covered over.

Tibbetts Brook flows into the Bronx's leafy Van Cortlandt Park, where it fills a small lake dammed in 1690 to power a sawmill and gristmill. The brook then dives underground at Tibbett Avenue and flows through a double-channeled sewer to the Harlem River Ship Canal.

Perils of Life in the Big Apple

From the New York Herald, August 30, 1869,

> *We advise timorous people who one property below Canal Street to look out. There are geologists who would insinuate that the southern end of Manhattan rests on a basaltic arches, against which the currents of a vast subterranean river dash, and thus 500 or 1,000 years hence the lower part of the island will cave in!*



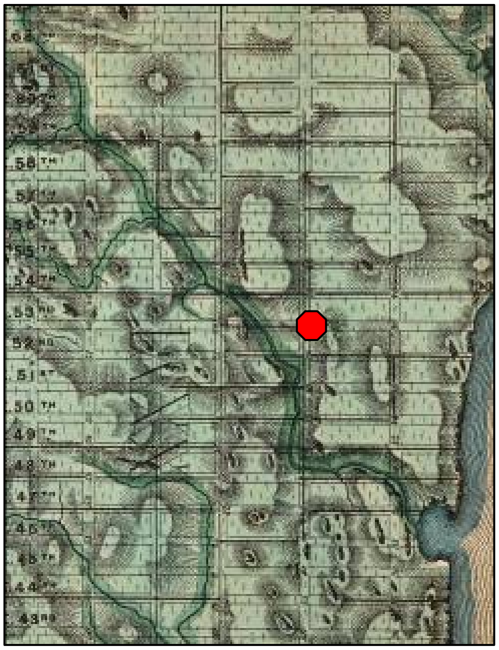
The Fantom of the Fair comic book first appeared in 1939. The Fair was the New York World's Fair of 1939-40. The Fantom's headquarters beneath the Fair was equipped with a modern laboratory and was located right next to an underground river, apparently flowing below sea level. His mission was to protect visitors from the City's many criminals. His regular name was never revealed. Also unmentioned was a motive for becoming involved.

Basement Fishing

In an August 22, 1971, New York Times letter to the editor, columnist Jack Gasnick, reminisced in "A Manhattan Reminiscence" about the day some fifteen years before when he caught (and later consumed) an almost-three-pound carp in the basement of his hardware supply house at 53rd and Second.

> *We had a lantern to pierce the cellar darkness and fifteen feet below I clearly saw the stream bubbling and pushing about, five feet wide and up-on its either side, dark green mossed rocks. This lively riverlet was revealed to us exactly as it must have appeared to a Manhattan Indian many years ago.*
>
> *With plum-bob and line, I cast in and found the stream to be over six feet deep. The spray splashed up-wards from time to time and standing on the basement floor, I felt its tingling coolness.*
>
> *One day I was curious enough to try my hand at fishing. I had an old-fashioned drop line and baited a hook with a piece of sperm-candle. I jiggled the hook for about five minutes and then felt a teasing nibble. Deep in the basement of an ancient tenement on Second Avenue in the heart of midtown New York City, I was fishing.*
>
> *Feeling a tug, I hauled up in excitement and there was a carp skipping before me, an almost three pounder. I was brave enough to have it pan-broiled and buttered in our upstairs kitchen and shared it with my brother...*
>
> *But this is all in the past. My little stream is no more! The Corning Glass Building at 56th Street and Fifth Avenue has used up all the water….*

The Viele map shows the proximity of 53rd and Second to an historic stream course.



Gen. Viele wasn't as accurate in hydrogeologic matters, however, as he was in his mapping. As interviewed in the April 28, 1901, New York Times "Subterranean Brook Tapped in Building,"

> *Manhattan Island is on a spur of the upland ledge of the Appalachians, and in my study of Central Park territory I became familiar with the natural scheme of the island's gridiron of water connections. All these natural outlets for water, some of which, for all we know, may come from Lake George, should have been attended to as we attended to them on the west Plateau.*

As Lake George is in New York's Adirondacks, some 300 kilometers to the north, the General perhaps should have stuck to his knowledge of Central Park.

John Waldman, an aquatic biologist at Queens College and the author of Heartbeats in the Muck, The History, Sea Life and Environment of New York Harbor, found the fish yarn “very interesting,” adding, “It is possible, but it would have taken very peculiar and unlikely circumstances for this to have happened.”

According to Dr. Waldman, it was possible that these hardy creatures survived in this unlikely habitat after having been spawned prior to the complete landfilling of the stream. It also was possible that someone dumped them into this underground rivulet at a later point. The least likely scenario would have been that they were maintaining an ongoing population. But regardless of how they got there, what food sources could have sustained them? As food must be exported to subterranean waters in the absence of photosynthesis, such carp must either have been receiving food from scraps derived from the photosynthetic-based ecology of surface waters or someone was feeding them.

When asked whether any carp could be found swimming under Manhattan today, Dr. Waldman said it was virtually impossible. “Fish don’t live in the dark for generations. It just doesn’t happen.”

We can't abandon the sport of basement fishing, however, without noting a news item, "Chinese Farmer Digs Hole in Kitchen to Fish," World Entertainment News Network, June 22, 2009.

> *A Chinese farmer hired 30 villagers and spent six months digging a hole to reach an underground river he suspected was full of fish underneath his kitchen.*

We're left unsure if the farmer's catch was better than that achieved in Manhattan.

And if that's not enough about subterranean streams beneath the famed city, we have the 1989 movie sequel Ghostbusters II. To quote the publicity,

> *Sidelined after their spectacular save of New York City five years ago, the heroes once again answer the call when an underground river of ghoulish goo threatens to rot the Big Apple to the core.*

And here we'll depart New York City, Gotham of many underground rivers, and head to Massachusetts, where there was said to be just one.

CHAPTER 82
ALLIGATORS BELOW

We've all heard it:

> A pet alligator raised in New York City becomes too large for the apartment and is flushed down the toilet. In the Manhattan sewers, tropically-warm and abundant in meaty rodents, the reptile thrives...

The legend's part of what makes New York, New York.

As we've come to discover, tales of underground rivers braid and migrate. As our journey is one of sequential chapters, however, we must place this particular portion in a single section, though it might also fit in others.

This chapter, for example, might be slipped into

Chapter 68, More Perils, as illustrated to the right.

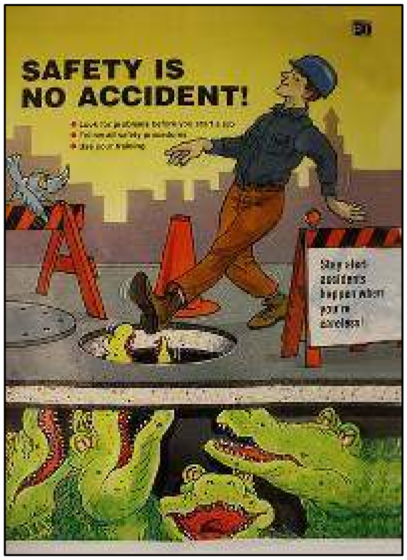
Chapter 21, Boys Club Singles, as a seminal event involved a 1935 Boys Club, one member fortuitously "an expert on Western movies" with requisite skills.

Chapter 47, Wrecks of Ancient Life, as we are very much concerned with an animate creature.

Chapter 79, Veins of the Heartland, as our particular creature is the species Alligator mississippiensis.

Chapter 58, The Grand Tour, European Sewers of Distinction, as this is also about sewers.

Chapter 81, East Side, West Side, All Around the Town, where our en-situ alligator witness, according to the May 31, 1954, New York Times,


SAFETY IS
NO ACCIDENT!
Stay alert: accidents happen when you're careless!

> *Knows some fifty underground streams -- where they are trapped into the sewers and where they trickle and course around them, stubbornly burbling under the countless tons of asphalt and concrete, in approximately the same beds they followed when the island was lush green.*

This material could even be slipped into Chapter 73, The Sinking of the Fleet, because Londoners of 1851 believed that the by-then-subterranean River Fleet to be inhabited by feral pigs, the folklorific antecedent to the remainder of this chapter.

Among the Hampstead, London shore-workers ran the story that a sow by accident entered the underground river through an opening, and in the drain littered and reared her offspring, feeding on the offal washed into it. The breed multiplied exceedingly, becoming almost as ferocious as they were numerous. The subterranean animals could only return to the light by reaching the Thames, but to do so, they must negotiate the Fleet ditch, which runs with great rapidity. Given the obstinate nature of a pig to enter a current, the wild hogs kept to their new-found quarters. There were, however, no records of Hampstead residents having seen such animals pass beneath the gratings, nor having been disturbed by their gruntings.

And now we go to America, where pigs become alligators.

As reported by The Planet, Union Village, N.Y., July 18, 1831,

> *A live alligator, it is said, was seen Friday in the slip between Murray's and Pine Street warves, New York.*

The New York Times continues the chronicle of like stories.

July 21, 1907, "Alligator in the Sewer, Quite a Baby, But it Nipped the Hand of the Finder,"

> *Charles Gidds of Duke Street, Kearny, N.J., is employed as Superintendent in the Kearny Street Department. He was clearing out a sewer Friday, when a workman called his attention to a strange object in the water. Gidds, picked it up, but suddenly dropped it with a yell.*
>
> *Workmen then examined the object, which proved to be a young alligator about eighteen inches long. It had nipped Gidds in the right hand, but inflicted little injury.*
>
> *It was learned later that the alligator had escaped a week ago from Freeholder John W. Roache, and who welcomed its return with many thanks.*

September 4, 1927, A "good-sized Florida alligator" found in a storm-swollen stream in Middletown, NY.

> *It was later discovered that the alligator had escaped several months ago from a pan on the premises of Dr. F.E. Fowler.*

July 3, 1929, A 2-foot alligator found in the grass at a residence in Port Jervis, N.Y.

May 22, 1931, Another 2-foot specimen found in the bushes on a Westchester County estate

June 30, 1932, An alligator hunt by Westchester County police after

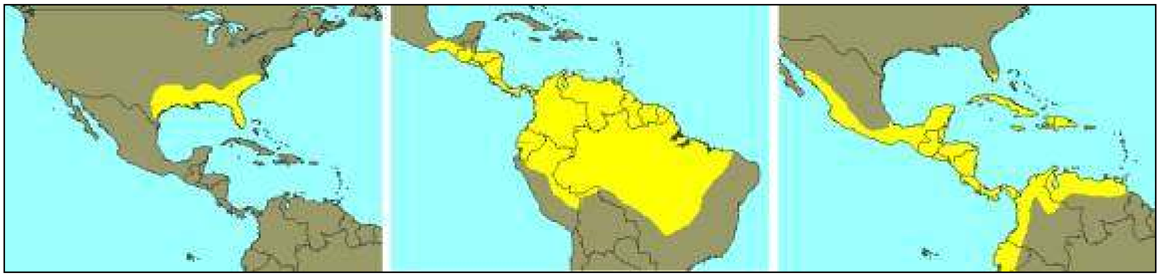
> *Two small boys had appeared at headquarters last night to show the chief a dead alligator, about 36 inches long, which they said they had captured along the shore of the lake. The boys told the chief that the Bronx River, of which the lake is a part, had been 'swarming' with at least two or three other alligators.*
>
> *The start of the explorers was delayed today because of fear on the part of the police chief that a species of human beings, known as baseball players, who congregate on the shores of the lake, would interfere with the expedition.*

What ciivic-minded Boys Club wouldn't want to assist?

> *The proper method of catching an alligator alive was the subject of a conference this afternoon between the police chief and his men... Someone suggested that one of the police explorers, who sings bass in the police quartet, ought to practice the alligator mating call, which the police chief learned was a cross between the bark of a dog and the grunt of a pig.*
>
> *A hurried visitor to Police Headquarters told the police chief that a piece of liver would make an alligator literally walk across the water to shore and that it could be captured alive easily with the type of net generally used by butterfly chasers.*
>
> *The police chief put in a requisition for enough liver to feed a good-sized alligator, and one of his men promised to lend the explorers a fishing net for the expedition.*

July 2, 1932, The hunt was called off after it was deemed that the boys had seen snakes or lizards in the river, not gators. The carcass they'd found was identified as a pet crocodile which had escaped from a neighbor's backyard a few weeks before.

Perhaps we should pause to note some issues of reptilian identification. In reporting a sighting, the newspapers almost inevitably used "alligator." The size of the creatures, however, is often more in the range of a caiman. As for crocodiles, according to the account above, at least, they might be present, as well.



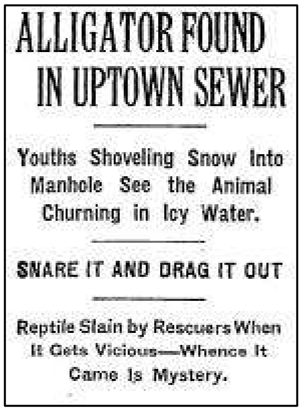
American Alligator	Common Caiman	American Crocodile
(Alligator mississippiensis)	(Caiman crocodilus)	(Crocodylus acutus)
Maximum length: 4 to 4.5 meters	2 to 2.5 meters	3.5 to 5 meters

September 12, 1933, Belleville, N.J.,

> *A squadron of riflemen was organized here today to hunt for alligators in the Passaic River... Belleville police said it is probable the alligators were some of the six reptiles which disappeared last year from a lagoon in Military Park, Newark.*

Subterranean Abode

All exciting reptilian stories, of course, but above ground. Not until 1935 did the lair shift to beneath the sidewalks.



ALLIGATOR FOUND IN UPTOWN SEWER

Youths Shoveling Snow Into Manhole See the Animal Churning in Icy Water.

SNARE IT AND DRAG IT OUT

Reptile Slain by Rescuers When It Gets Vicious—Whence It Came Is Mystery.

February 10, 1935,

> *Youths Shoveling Snow into Manhole See the Animal Churning in Icy Water, Snare it and Drag it Out*
>
> *Reptile Slain by Rescuers When it Gets Vicious -- Whence it Came is Mystery.*
>
> *The youthful residents of East 123rd Street, near the murky Harlem River, were having a rather grand time at dusk yesterday shoveling the last of the recent snow into a gaping manhole.*
>
> *Salvatore Condulucci, 16 years old, of 419 East 123rd Street, was assigned to the rim. His comrades would heap blackened slush near him, and he, carefully observing the sewer's capacity, would give the last fine flick to each mound.*
>
> *Suddenly there were signs of clogging ten feet below, where the manhole drop merged with the dark conduit leading to the river. Salvatore yelled, "Hey, you guys, wait a minute," and got down on his knees to see what was the trouble.*
>
> *What he saw, in the thickening dusk, almost caused him to topple into the icy cavern. For the jagged surface of the ice blockade below was moving; and something black was breaking through. Salvatore's eyes widened; then he managed to leap to his feet and call his friends.*
>
> *"Honest, it's an alligator!" he exploded.*
>
> *Others Look and Are Convinced.*
>
> *There was a murmur of skepticism Jimmy Mireno, 19, of 440 East 123rd Street, shouldered his way to the rim and stared.*
>
> *"He's right," he said.*

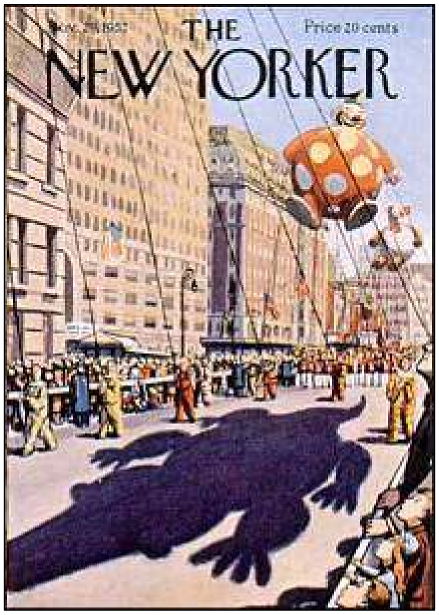
> *Frank Lonzo, 18, of 1743 Park Avenue, looked next. He also confirmed the spectre. Then there was a great crush about the opening in the middle of the street and heads were bent low around the aperture.*
>
> *The animal apparently was threshing about in the ice, trying to get clear. When the first wave of awe had passed, the boys decided to help it out. A delegation was dispatched to the Lehigh Stove and Repair Shop at 441 East 123rd Street.*
>
> *"We want some clothes-line," demanded the delegation, and got it.*
>
> *Young Condolucci, an expert on Western movies, fashioned a slip knot. With the others watching breathlessly, he dangled the noose into the sewer, and after several tantalizing near-catches, looped it about the 'gator's neck. Then he pulled hard. There was a grating of rough leathery skin against jumbled ice. But the job was too much for one youth. The others grabbed the rope and all pulled.*
>
> *Slowly, with its curving tail twisting weakly, the animal was dragged from the snow, ten feet through the dark cavern, and to the street, where it lay, non-committal; it was not in Florida, that was clear.*
>
> *And therefore, when one of the boys sought to loosen the rope, the creature opened its jaws and snapped, not with the robust vigor of a healthy, well-sunned alligator, but with the fury of a sick, very badly treated one. The boys jumped back. Curiosity and sympathy turned to enmity.*
>
> *"Let 'im have it!" the cry went up.*
>
> *Rescuers then Kill It.*
>
> *So the shovels that had been used to pile snow on the alligator's head were now to rain upon it. The 'gator's tail swished about a few last times. Its jaws clashed weakly. But it was in no mood for a real struggle after its icy incarceration. It died on the spot.*
>
> *Triumphantly, but not without the inevitable reaction of sorrow, the boys took their victim to the Lehigh Stove and Repair Shop. There it was found to weigh 125 pounds; they said it measured seven and a half or eight feet. It became at once the greatest attraction the store ever had had. The whole neighborhood milled about, and finally, a call for the police reached a nearby station.*
>
> *But there was little for the hurrying policemen to do. The strange visitor was quite dead; and no charge could be preferred against it or against its slayers. The neighbors were calmed with little trouble and speculation as to where the 'gator had come from was rife.*
>
> *There are no pet shops in the vicinity; that theory was ruled out almost at once. Finally, the theories simmered down to that of a passing boat. Plainly, a steamer from the mysterious Everglades, or thereabouts, had been passing 123rd Street, and the alligator had fallen overboard.*
>
> *Shunning the hatefully cold water, it had swum toward shore and found only the entrance to the conduit. Then after another 150 yards through a torrent of melting snow -- and by that time it was half dead -- it had arrived under the open manhole.*
>
> *Half-dead, yes, the neighborhood conceded. But still alive enough for a last splendid opening and snapping of its jaws. The boys were ready to swear to that.*
>
> *At about 9 p.m., when tired mothers had succeeded in getting most of their alligator-conscious youngsters to bed, a Department of Sanitation truck rumbled up to the store and made off with the prize. Its destination was Barren Island and an incinerator.*

After this oft-cited adventure, however, New York area alligator encounters reverted to those above ground.

March 8, 1935	"A 3-foot gator was found in Northern Yonkers by Joseph Domomico yesterday morning. Another twice that size was found, dead, on the east side of Grassy Sprain reservoir."

June 1, 1937	A 4-foot alligator captured by a barge captain at Pier 9 in the East River. The gator "was clearly exhausted and seemed in no humor to fight."
June 7, 1937	"Passengers waiting on the eastbound platform of the Brooklyn Museum station of the I.R.T. subway just before midnight were startled by the sudden appearance of a 2-foot alligator which had emerged from a refuse can. Passengers on the station told the police that shortly before the alligator appeared a man put a large bundle in the refuse can."
August 16, 1938	Five alligators caught in Huguenot Lake (Westchester, NY), the largest of which was 19 inches.
August 17, 1942	A 4-foot alligator (thought to have escaped from an outdoor aquarium in a local home) found in Lake Mindowaskin near Westfield, NJ).

New Yorker, November 29, 1952. The magazine provides no comment on this illustration, but it's clearly inspired by the sewergator legend.

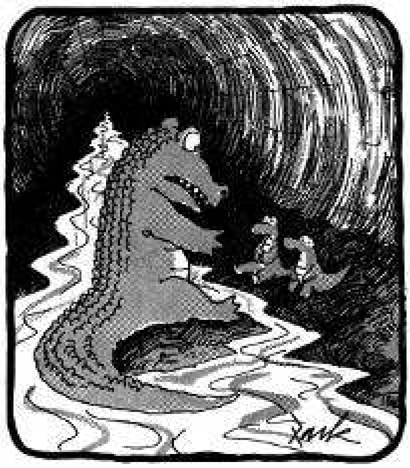


From Where Come the Gators?

Alligator sighting were generally attributed to creatures recently escaped from captivity. The May 31, 1954, New York Times report on Superintendent of Sewers, Edward P. May's retirement at age 80 included this tidbit, however.

> *He has cleared the system of a rash of alligators. Dropped in by harassed parents when the reptiles were tiny pets, they grew amazingly.*

Thus an urban legend is established.



"They say that sewer workers sometimes escape to the above where they grow to enormous size."

While the New York Times dutifully called May "Superintendent of Sewers" and subsequent sources frequently promote him to "Commissioner of Sewers," his April 14, 1960, obituary noted that he was made "Honorary Commissioner of Sewers" at his retirement at age 80, some six years earlier.

One who would know of such rank would be John T. Flaherty, Chief of Sewer Design, Bureau of Sewers, NYC, as quoted by Jan Harold Brunvand in Too Good to Be True (1999).

> *Yes, Professor, there really was a Teddy May... almost as much of a legend as the New York City Sewer Alligator itself...* [He] *was a sewer worker who, in the fullness of time, rose to become a Foreman or, perhaps, a District Foreman.*

May's proper title is not the issue, of course, but rather his sway, and that he wielded over his administrative superiors. He alone knew the workings.

Flaherty continues,

> *Teddy was a very outgoing, ebullient man with a wide circle of friends and an even wider circle of admiring acquaintances. Part of his charm was his undoubted abilities as a raconteur and a spinner of yarns*

"Chew-tobacco Teddy," they called the salty union-speaker -- professional evidence against the title "Commissioner" -- who knew first-hand every foot of the 560-mile sewer system.

Teddy May would come to be the source for Robert Daley's "Alligators in the Sewers" in The World Beneath the City (1959), the reference which would propel the alligator story from newsprint to library shelves.

According to May, sewer inspectors first reported seeing alligators in 1935, but he didn't believe them.

> *I says to myself, "Them guys been drinking." I'll go down there and prove to youse guys that there ain't no alligators in my sewers.'*

Once he looked, May saw the alligators, most about two feet long and living in the smaller pipes. May dispatched his men to dispatch the invaders, some by rat poison, others shooed into trunk lines where rapid flow carried them to the harbor, and some by .22 rifles and pistols. New York City sewers were alligator-free in but a few months.

Somewhat surprisingly -- New York Times prone to relish alligator stories -- the extermination campaign wasn't reported in the press. No ex-sewer worker but May has recalled the task.

The war-against-the-reptiles saga thus entirely rests on the word of a crusty ex-bricklayer regaled for his entertaining stories.

May made no mention of blind or albino alligators -- a folkloric embellishment influenced by the characteristics of troglobites, we expect -- and suggested that the pets were dumped down storm drains rather than flushed down the toilet, a reasonable conjecture, given residential drain-pipe diameters.

Albino alligators do exist, however, though the condition is genetic, not environmental. Meet Dinah of Knoxville Zoo.

In the novel V (1963), author Thomas propelled the persistent rumors of sewer alligators into a major work of fiction.

> *Did he remember the baby alligators last year, or maybe the year before, kids all over Nueva York bought these little alligators for pets. Macy's was selling them for fifty cents; every child, it seemed, had to have one. But soon the children grew bored with them. Some set them loose in the streets, but most flushed them down the toilets. And these had grown and reproduced, had fed off rats and sewage, so that now they moved big, blind, albino, all over the sewer system. Down there, God knew how many there were. Some had turned cannibal because in their neighborhood the rats had all been eaten, or had fled in terror.*

Slithering through the underground rivers, the alligators were blind and albino, fat on rats. Pynchon's Alligator Patrol worked in teams of two, one man holding the flashlight, the other a 12-gage shotgun.

Weaving the alligators-in-the-sewers motif throughout, V thus brought the urban lore further into popular culture.

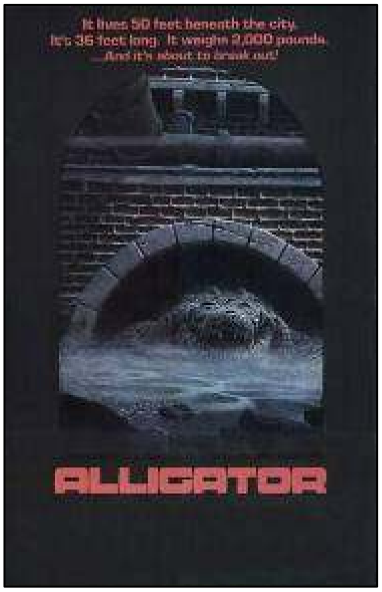
The alligators-in-the sewer tale was well known by the late 1960s, when, according to Richard M. Dorson's America in Legend (1973), seekers of the potent "New York White," an albino marijuana strain growing from seeds flushed down the toilet during drug raids, feared harvesting the product.

> *Because, according to a newspaper story, full-grown alligators prowled the sewers of New York. It seems that Miami vacationers returning to New York in the winter brought back baby alligators as pets for their children. The more the alligators grew the less ideal they appeared as playmates, and their owners, too tender hearted to skin them for their hides, mercifully flushed them down the toilet. Some survived in their new environment and confronted sewer maintenance workers, who publicly protested at this unnecessary additional hazard to their occupation.*

Those most affected, the pot-growers, of course couldn't publically protest.

The line underground river alligator outside of New York appears to be the monster prowling Chicago sewers in John Sayles's 1980 Alligator, a Jaws knock-off.

The movie predictably spawned Alligator II -- The Mutation (1996), but despite the Roman numeral, the second film shared no characters or actors with Sayle's original.


It lives 50 feet beneath the city.
It's 36 feet long. It weighs 2,000 pounds.
...And it's about to break out!
ALLIGATOR

The Debate

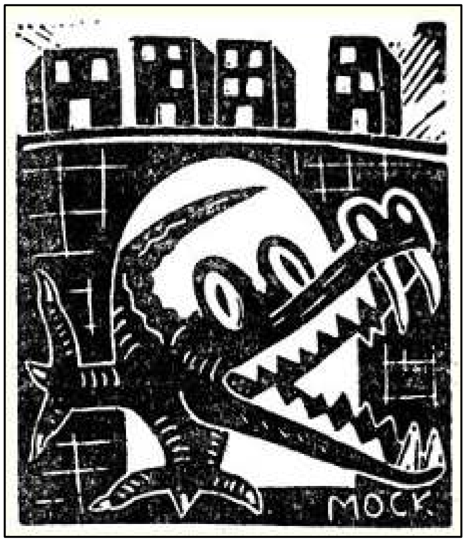
By now, the underground river tale was evoking academic attention.

"Debunking the Myth of Subterranean Saurians," New York Times, May 19, 1982, by Anna Quindlen merits substantial quotation.

> *Like Captain Hook, John T. Flaherty is dogged by crocodiles, and, in addition, alligators. Mr. Flaherty is chief of design in the New York City Bureau of Sewers, but he is also the resident expert on the most durable urban myth in the history of cities, reptiles or waste disposal.*
>
> *"Dear Sirs," writes a correspondent from Stockholm, where sewers are called cloaks, "I take the liberty to write to you, since I from many sources have been informed that, for many years, a substantial number of krokodiles have found themselves a suitable atmosphere of living in the cloak tunnels of New York."*
>
> *And a man from Celoron, N.Y., writes: "I disagree with a coworker whom insists that an alligator which had lived in a sewer system over a long period of time does not change color. I said I believe the pigmentation of the alligator would become much lighter and in some cases turn almost white." To all these Mr. Flaherty, a good-humored man with an alligator cigarette lighter on his desk, must reply, "No, Virginia, there are no alligators in the New York City sewer system."*
>
> *In the "sewer game," as Mr. Flaherty calls it, which is not a glamour business; this has made John T. Flaherty something of a celebrity. There is even a makeshift star on his door, and a mock-up of a Variety headline that reads, "Flaherty says new alligator in sewer movie is a filmflam and is nothing but a croc."*
>
> *Alligators have become Mr. Flaherty's sideline, and he handles them with flair. The myth is that travelers to Florida adopted the baby reptiles, tired of them and flushed them down the toilet and into the city sewer system, where they grew to immense size.*
>
> *To the man from Celoron who thought alligators would pale below ground: "I could cite you many cogent, logical reasons why the sewer system is not a fit habitat for an alligator, but suffice it to say that, in the 28 years I have been in the sewer game, neither I nor any of the thousands of men who have worked to build, maintain or repair the sewer system has ever seen one, and a 10-foot, 800-pound alligator would be hard to miss. Of course, following the*

> *thought that you advance in your letter to its ultimate conclusion, perhaps the pigmentation affect has been so radical that they have been rendered invisible."*
>
> *There are, however, no alligators, because, Mr. Flaherty says, there is not enough space, there is not enough food -- "the vast majority of it has been, to put it as delicately as possible, predigested" -- and the torrents of water that run through the sewers during a heavy rain would drown even an alligator.*
>
> *He adds that one clear proof of the absence of alligators is that not a single union official has ever advanced alligator infestation as a reason for a pay increase for sewer workers.*

Donald F. Squires, Director, New York Sea Grant Institute, responded a month later with "On the Incidence of Alligators and Hard Times." A Richard Mock linocut provided some artwork.



> *To the Editor:*
>
> *Anna Quindlen's May 19 news story "Debunking the Myth of Subterranean Saurians" did a great disservice to true believers. John Flaherty (Chief of design in the New York City Bureau of Sewers), whom she quotes, professes that "there are no alligators in the New York City sewer system." I protest!*
>
> *No less a source than "All the News That's Fit to Print" reported a veritable rash of "saurian sightings" in the city sewers through the 1930's. Our research on this subject is limited, because, in truth, we were looking for giraffes. The alligators were serendipitous.*
>
> *At any rate, we refer Miss Quindlen and Mr. Flaherty to The Times for February 10, 1935, which reports a brave lad, Salvatore Condulucci, and his friends attacking an eight-foot alligator with snow shovels on East 123d Street. Some other reports that appeared in The Times:*
>
> *June 30, 1932 -- alligators in the Bronx River;*
> *September 12, 1932 -- alligators in New Jersey;*
> *June 1, 1937 -- alligators in the East River;*
> *June 7, 1937 -- alligators in the Brooklyn subway!*
>
> *As I have suggested in our newsletter, Coastlines, there may be a relationship between economic hard times and an outpouring of alligators, as evidenced by the reports in The Times. Perhaps Mr. Flaherty should become prepared.*

An official of the Sea Grant Institute would of course defend resident aquatic reptiles.

Flaherty, as we might expect, could not let the challenge pass. From "New York Underground Still Free of Alligators," New York Times, July 17,

> *To the Editor:*
>
> *I read with interest the June 9 letter of Donald F. Squires protesting my contention, as reported by Anna Quindlen in her excellent May 19 news article, that there are no alligators in the New York City sewer system. Yet, examined dispassionately, his letter seems to bear out my position.*
>
> *For example, when one looks at the synthesis of the five Times articles of the 1930's offered by Mr. Squires as evidence of the existence of Alligator Cloaca Novum Eboracum, one finds reports of alligators in the Bronx River, in the East River, in New Jersey (a gratuitous thrust, as I have never commented on the presence of alligators in the Garden State) and even on East 123d Street, Manhattan. However, in none of these articles, at least as Mr. Squires reports*

DRAFT 12/6/2012

> *them, is there any mention of an alligator actually being found in a sewer! (I do not know his feelings about the Brooklyn subway, but, despite certain similarities that go beyond the fact both are underground, I do not consider the Brooklyn subway to be a sewer in the classical meaning of that word.)*
>
> *In the 28 years I have been in this business, neither I nor anyone else connected with the sewer game has ever spotted an alligator in a sewer -- or anywhere else, for that matter. Since the most recent article cited by Mr. Squires is dated June 7, 1937, fully 45 years ago and 17 years before my odyssey in the sewers began, and since I am sure that Mr. Squires, whose zeal for his cause is to be admired, would have produced more recent evidence had it been available, I feel that, however inadvertently, he has further vindicated my stand.*
>
> *Mr. Squires' theory correlating the reported sightings of alligators in the Big Apple with economic hard times is fascinating. However, if one must search for a sociological explanation for this phenomenon of the 1930's, I, myself, would be more inclined to associate it with the repeal of Prohibition.*

Related stories keep appearing.

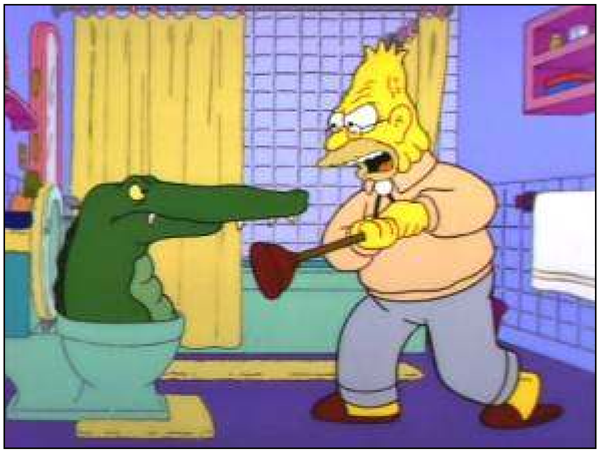
Twenty-kilogram snapping turtles found in New York wastewater treatment plants in the late 1980s.

A 4-meter pet python found at Philadelphia's Northeast treatment plant -- dead.

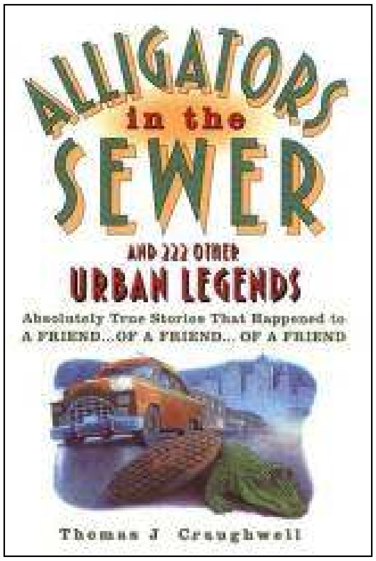
In 1994, alligator spotted near a reservoir in Westchester County, probably a pet or an escapee from a wildlife park.

From the New York Times, July 1, 2001,

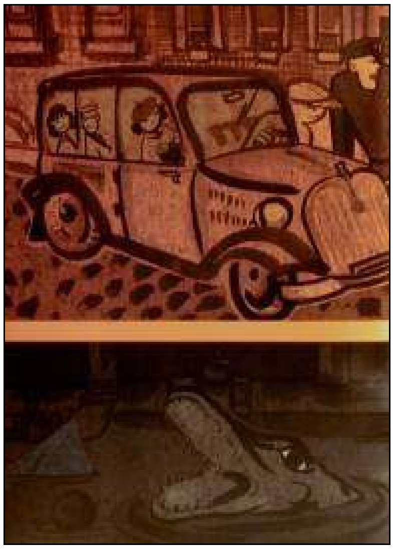
> *The baby alligator sighted in Harlem Meer in Central Park was actually a baby spectacled caiman.*



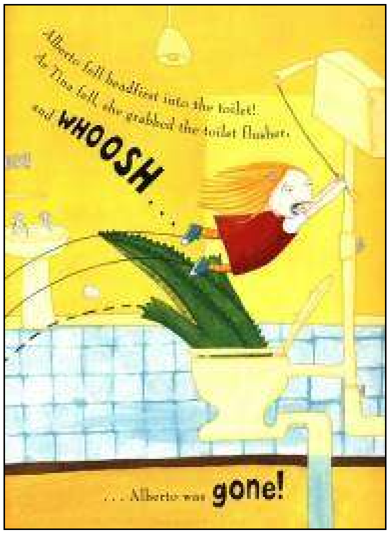
The bellwether of popular culture, "The Simpsons." From the episode of May 6, 1993. Bart: "We flushed the gator down the toilet, but it got stuck halfway, and now we have to feed it."


ALLIGATORS
in the
SEWER
AND 222 OTHER
URBAN LEGENDS
Absolutely True Stories That Happened to
A FRIEND...OF A FRIEND... OF A FRIEND
Thomas J Craughwell

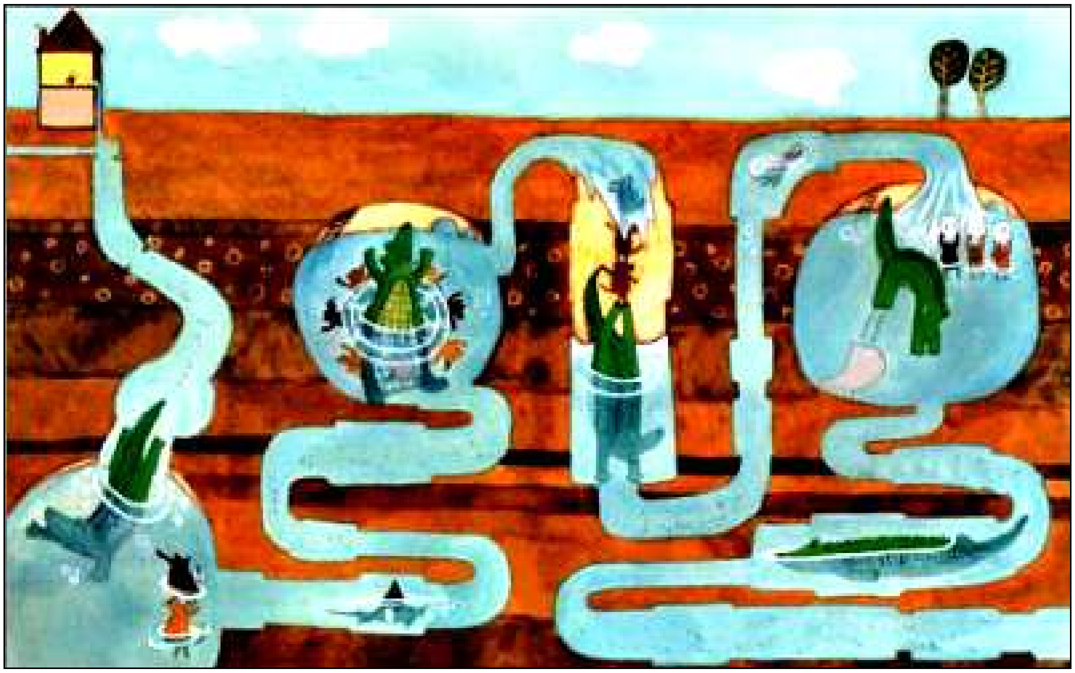
Alligators in sewers certainly merit a book, thus Thomas Craughwell's by that very title in 1999.



An illustration from Under New York (2001) by Linda Oatman High


Alberto fell headfirst into the toilet!
As Tina fell, she grabbed the toilet flusher,
and WHOOSH . . .
. . . Alberto was gone!

The geologic strata from Richard Waring's Alberto the Dancing Alligator (2002) -- which does not appear to be situated under New Your City, by the way -- is shown below.



The band Radiohead's recorded "Alligators in the Sewers,"

> *Baby alligators in the sewers grow up fast,*
> *Grow up fast,*
> *Anything you want it can be done,*
> *How did you go bad?*

But perhaps, we must admit, our search of underground rivers hasn't netted actual 'gators, but that's proper for a lasting urban legend. We've enough pieces, each somewhat tying to something that might be so.

We'll conclude our alligator-and-human-made-underground-river chapter with a few quotations.

Herpetologists, Sherman and Madge Rutherford Minton,

> *One of the sillier folktales of the late 1960s was that the New York sewers were becoming infested with alligators, presumably unwanted pets that had been flushed down the toilet. In some accounts, these were growing to formidable size from feeding on rats. We have been unsuccessful in tracing the source of these legends but would assure New Yorkers that alligators are not among their urban problems.*

Folklorist, Jan Harold Brunvand,

> *The theme of displaced creatures is an old one, and modern folklore has spawned many rumors of an animal -- usually a fearsome one -- lurking where it does not belong.*

Herpetologist, Frank Indiviglio,

> *I would bring leftovers from lunch, a long line and a hook, and spend a part of each day in the sewers looking for alligators. I saw rats, cockroaches -- probably caught a lot of sicknesses -- but I never saw anything like an alligator.*

Folklorist, Gary Alan Fine,

> *What could better serve as a metaphor for the city as a jungle than the belief that the New York sewer system is filled with albino alligators, which swim through toilet pipes and bite victims in public washrooms?*

Nature writer, Diane Ackerman,

> *But they couldn't survive for any length of time in the sewers, only a few months at the most, because they can't live long in salmonella or shigella or E. coli, organisms that one usually finds in sewage. Also, alligators live at temperatures between 78 and 90 degrees... Despite the dearth of news stories about NY alligators and in the face of what we know about how gators are put together, the "alligators in the New York sewer system" stories persist.*

New York City sewer worker, Esteban Rodriguez,

> *It’s like the Loch Ness Monster or the Big Foot. People believe in those stories up to a point that it does make sense.*

Acting Commissioner, Department of Environmental Protection, New York City, Steven Lawitts,

> *We have had no alligator sightings dead or alive, except on our T-shirts.*

Official NYC
Alligator T-Shirt
$16.00

The Legend Lives...

Salvatore Condolucci, 92, the "expert on Western movies" who roped the alligator in 1935, interviewed in the New York Times, November 24, 2009. Condolucci remembered the thrashing within the manhole, the creature's head, the lassoing and hauling it to the surface. But as to whether others lurk there today,

> *I don't know. I really don't know.*

CHAPTER 83

PROFESSOR DENTON'S NEW ENGLAND UNDERGROUND RIVER

The Professor

We will begin with a brief biography of our central character, Professor William Denton. We will take care, however, to not confuse our protagonist with the William Denton, a few years older, an Anglican clergyman who shared an interest (though not a position) regarding matters of the spirit, and "Professor Denton" of Brooklyn, "the champion gin fizz drinker in America," the renown rascal of some decades later who shared our Denton's distaste for conventional opinion.

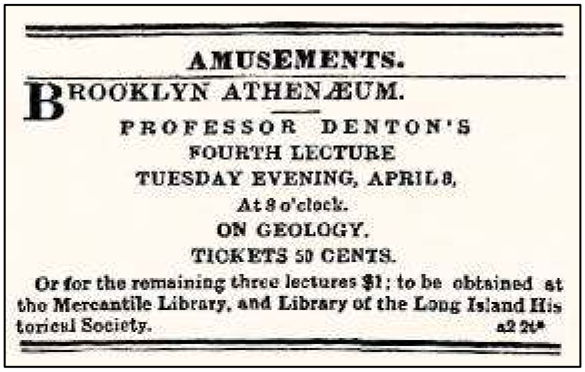
Our William Denton was born to a Durham County, England family of little means in 1823. Though his schooling was rudimentary, he was a quick learner and a born expositor. By age 16 he was a lecturer on temperance, Methodism and mesmerism and at age 25 he immigrated to America, penniless, but brimming with ambition.

Relentless self-education coupled with charisma secured him a series of school-teaching positions in Pennsylvania, western Virginia and Ohio, bur each was short-lived as his interests expanded to include abolition, Darwinism the new-found science of "psychrometry," a person's ability to see in a physical object all that has ever happened to that object.

At 31, Denton met and married a kindred sprit, Elizabeth Foote (she was known to wear bloomers) and made his way into the Lyceum circuit, propounding a mixture of spiritualism and modern science. He was good on stage, as four years he was debating future-president James Garfield in the subject of "Geology and Religion," arguing against the latter.

Denton's sister, Annie Denton Cridge, obviously of like stock, was meanwhile becoming a spokeswoman for feminism, cooperative kitchens and workshops and other disturbing ideals.

Denton toured throughout the United States and Canada, filling auditoriums at $0.25 or $0.50 a head and within seven years had earned enough to build a house on 13 acres in Wellesley, Massachusetts on what today is Denton Street.



AMUSEMENTS.

BROOKLYN ATHENÆUM.

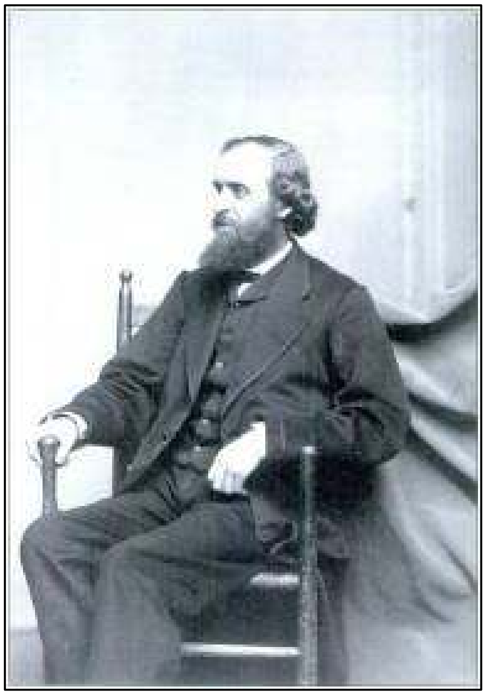
PROFESSOR DENTON'S
FOURTH LECTURE
TUESDAY EVENING, APRIL 8,
At 8 o'clock.
ON GEOLOGY.
TICKETS 50 CENTS.

Or for the remaining three lectures $1; to be obtained at the Mercantile Library, and Library of the Long Island Historical Society. a2 2t*

Books authored by Benton included, for sale at his lectures at $1.00 or $1.50 included,

Nature's Secrets (1863)
The Soul of Things; or Psychometric Researches and Discoveries (1863), with his wife Elizabeth
Our Planet, Its Past and Future, or Lectures on Geology (1869)
The Deluge in the Light of Modern Science, A Discourse (1869)
Irreconcilable Records, or Genesis & Geology (1872)
What Was He? or, Jesus in the Light of the Nineteenth Century (1877)
Is Darwin Right?, or The Origin of Man (1881)

Denton's wife did the typesetting. As might be deduced from the titles, the author was smitten with the science of geology.



Excerpts suggest the author's intellectual framework. Psychrometry allowed him complex deductions from scant evidence.

> *From the first dawn of light upon this infant globe, when round its cradle the stormy curtains hung, Nature has been photographing every moment.* -- Nature's Secrets (1863)

His sense of nature was often accurate,

> *I have never visited the Mammoth Cave; but those who have will, I think, acknowledge the accuracy of the descriptions of the known parts of the cave. The truth of the statements with regard to the unknown portions future explorers may yet determine. The animal influence felt was probably owing to the fossils contained in the Mountain Limestone, in which the Mammoth Cave has been hollowed out, by the action of underground streams for ages.* -- The Soul of Things (1863)

At times, however, his geologic imagination got the best of him.

> *Small earthquake-shocks are often produced by masses of rock falling into subterranean cavities; some of these may be heard and felt for great distances. The motion of a passing locomotive can be distinctly felt in some houses a mile from the railroad.* -- Our Planet, Its Past and Future (1869)

And more than at times, his Darwinian bent propelled him beyond the pale.

> *The time will come when the land under Lake Erie will be of more value than the water within it; and, when that time comes, man will say to the waters, "March!" and they will go, leaving the land for man's occupancy. Its greatest depth is but too hundred and seventy feet, and its drainage would be an easy matter. In like manner, the lands of Lakes Michigan and Superior will be needed, demanded and obtained, and the sea be made to give up a large portion of its shallow shores to supply man's constantly-increasing demand for room.* -- Is Darwin Right? (1881)

In an April 16, 1881, review of Is Darwin Right?, the Scientific American noted of the author,

> *During his career as a popular lecturer he has undoubtedly done good work in combating the older unscientific traditions of the multitude. But the cast of his mind is essentially unscientific,*

> *and his knowledge would appear to have been gained essentially by reading. His book in interesting and suggestive, but it betrays throughout the incompetence of the author to grasp the exact conditions of the problem he attempts to answer.*

Denton was a news item, a snippet from the September 1, 1865, Buffalo Daily Courier being an example.

> *An exploring party, consisting of Professor Denton, Geologist, of Boston; Major Whitney and others returned today from an expedition through Western Colorado, between the Rocky Mountains and Utah. They report that they have made important discoveries of coal, petroleum and shale, on the proposed route of the Pacific Railroad. They also bring dispatches from General Hughes' corps, constructing the new wagon road to Salt Lake, which will shorten the distance fully too hundred miles.*

Denton was fearless in fostering his beliefs. From the Wanganui Chronicle, September 1, 1882,

> *It is stated that Professor Denton was hissed off the stage a few Sunday evenings ago, because he had said the Bible was a series of falsehoods.*

Perusing the newspapers of the day, one cannot help but note that our character seems to have had no given name; in news of his most-recent lecture, it’s just "Professor Denton" this and "Professor Denton" that.

Even the government seems to have been uninformed regarding Denton's given name. Annual Report of the United States Geological Survey of the Territories, Wyoming (1872) quotes "Professor Denton" as follows.

> *Professor Denton, who made an exploration of the country about one hundred miles south of the railroad, has given a graphic account of his discoveries, which shows very clearly the geographical extension of this formation. Near the junction of White and Green Rivers, partly in Colorado and partly in Utah, he describes an immense tertiary deposit, composed of a series of petroleum shales, one thousand feet in thickness, varying in color from that of cream to the blackness of cannel coal.*
>
> *Professor Denton also discovered in this region a deposit of petroleum coal, which appears identical with and would yield as much oil as the Albertite coal of New Brunswick. Another bed, resembling cannelite, was noticed, ten to twenty feet in thickness, which Professor Denton believes would produce fifty or sixty gallons of oil to the ton.*

The title "Professor" is itself somewhat murky. Our geologist never earned a university degree and never held any sort of conventional faculty position. The periodicals that expanded on the title alternated between Professor at Harvard (for which there is no evidence), Professor at Wellesley College (Wellesley indeed being his home town), Professor at Boston University (an honorific possibility, perhaps) and Professor of the Boston Society of Natural History (which would have accorded no such rank). Denton himself remained above the fray, never correcting any of them. Perhaps wishing to side-step professional censure, Denton refrained for affixing any title or degree to the author page in his many books.

We'll not even mention that he was said to have been the Wisconsin State Geologist, a dubious appointment for having visited that state during the Civil War to survey for metals.

Nor will we comment on the Professor's knowledge of basic science. Christian Wisdom, A Key to Lessons in Earth Life (1915) by Franklin Ellsworth Parker, published long after Denton's demise, credits "Professor Denton" as author of the book's chapter on geology. A sample,

> *All matter when analyzed is reduced to four elements.*

1. Carbon Magnetic	*Solid Earth*
2. Oxygen Magnetic	*Liquid Water*
3. Nitrogen Magnetic	*Gaseous Air*
4. Hydrogen Electric	*Solid or Gas Fire*

> *Although the chemist bases his calculations on atoms or molecules, never has one been isolated, weighed, or defined by science.*
>
> *The oceans have a combination of 12 salts with which to cleanse the cruder atom.*

Aristotle might have agreed in principal -- recall the earth, water, air and fire of Chapter 2 -- but physical chemistry was by this time a great deal advanced.

But credentials and scientific background aside, Professor Denton was at times astute in his geological opinion, his crowning achievement being his identification of a fossilized saber-tooth cat tooth, 24 centimeters in length, the breadth of the crown 9 centimeters, at Rancho La Brea, California.

He took the tooth and some other bones back to Massachusetts, but his report failed to generate interest within the scientific community. We can be certain, however, is that the artifact generated attendance for his traveling lectures.

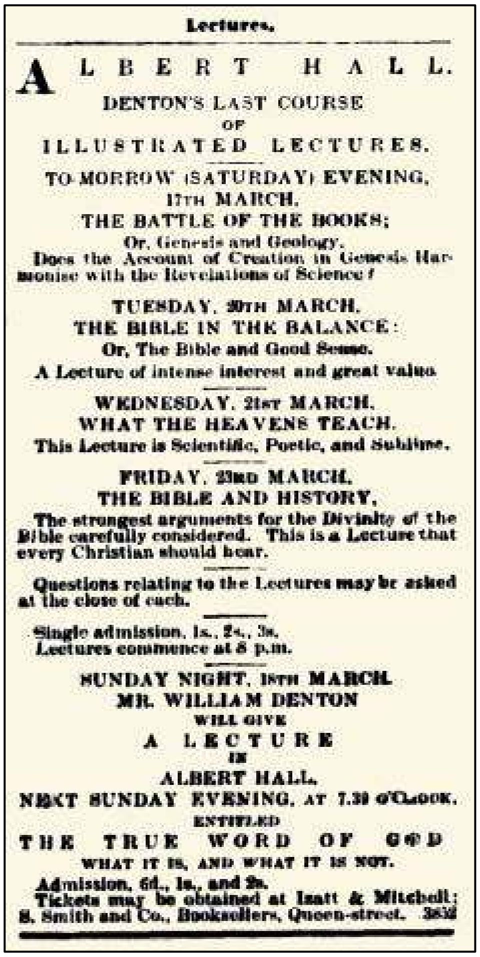
Unlike those who insisted that all lakes have outlets, subterranean as required, Denton recognized the actuality. From the Brooklyn Daily Eagle April 1, 1866, report on his lecture of the previous evening.

> *It is well known that any lake which has no outlet is necessarily salt, because the evaporation of water constantly going on leaves the salt, of which there is more or less in all water, in the lake... In Utah, Great Salt Lake in summer time, when water is low, furnishes water which produce one gallon of salt to three of water. Suppose the supply of fresh water be cut off such a body of water as has frequently been done by volcanoes in ages past, would not soon be a salt mine?*

We'll not expand upon Denton's association with the spiritualism movement of his time, other to say that he was an advocate. A web search today on the professor yields far more hits related to psychrometry than to geology. Regarding the latter, however, if we strip away the metaphysical extrapolation, what could be a better reduction of the science than the following?

> *Why could not rocks receive impressions of surrounding objects, with which they had been in immediate contact for years, and why could they not communicate the history of their relationship in a similar manner to sensitive persons?*

The lecture bill advertises Denton's topics.



Lectures.

ALBERT HALL.

DENTON'S LAST COURSE

OF

ILLUSTRATED LECTURES.

TO-MORROW (SATURDAY) EVENING,

17TH MARCH,

THE BATTLE OF THE BOOKS;

Or, Genesis and Geology.

Does the Account of Creation in Genesis Harmonise with the Revelations of Science?

TUESDAY, 20TH MARCH,

THE BIBLE IN THE BALANCE:

Or, The Bible and Good Sense.

A Lecture of intense interest and great value.

WEDNESDAY, 21ST MARCH,

WHAT THE HEAVENS TEACH.

This Lecture is Scientific, Poetic, and Sublime.

FRIDAY, 23RD MARCH,

THE BIBLE AND HISTORY,

The strongest arguments for the Divinity of the Bible carefully considered. This is a Lecture that every Christian should hear.

Questions relating to the Lectures may be asked at the close of each.

Single admission, 1s., 2s., 3s.
Lectures commence at 8 p.m.

SUNDAY NIGHT, 18TH MARCH.

MR. WILLIAM DENTON

WILL GIVE

A LECTURE

IN

ALBERT HALL,

NEXT SUNDAY EVENING, AT 7.30 O'CLOCK,

ENTITLED

THE TRUE WORD OF GOD

WHAT IT IS, AND WHAT IT IS NOT.

Admission, 6d., 1s., and 2s.
Tickets may be obtained at Izatt & Mitchell; S. Smith and Co., Booksellers, Queen-street. 3832

The Professor left his audiences satisfied. From the Brooklyn Eagle of April 12, 1866,

> *Resolved, that we have heard with interest, gratification and profit, the course of six lectures on the Science of Geology, delivered by Professor Denton. That while they have evinced his own study and mastery of the subject, his ability as a teacher and expositor of it, in its wonderful scope and manifold relations, has been marked and conspicuous, and demands our grateful acknowledgement.*

From the Syracuse Daily Journal, November 15, 1868

> *Imagine a beautifully written book, whose style is at once elegant, graphic, vivid and familiar; put that book on two legs, give it a ponderous finely balanced brain at the top, and an eloquent tongue of perfect fluency, and you have a facsimile of Professor Denton... A mind peculiarly adapted to the study of the earth's structure, history, present condition, and future career, has by tears of enthusiastic, but patient study, research, travel, analysis and logical inference, made itself just as familiar with this whole grand field of inquiry, as you and I are with our daily avocations. The talks, as it were, not in sentences, but in pictures. His own splendid faculty or realization compels his audience to see and think with him.*

But why, we may ask, have we devoted so many paragraphs to a suspect geologist, albeit a renowned Chautauqua lecturer?

Because, we must answer, our Professor, apparently in the course of a consultancy for New England's millenary industry, discovered a great underground river.

Well, we must hasten to admit, the discovery was not in the sense of personal inspection, but rather via psychrometry.

Once such a geologic marvel is discovered, of course, it persists even if no one else can find it.

The New England Underground River

In the preceding chapter, we noted the 1900 Lewiston Evening Journal's suggestion that the New York City water supply be taken from the White Mountains of New Hampshire.

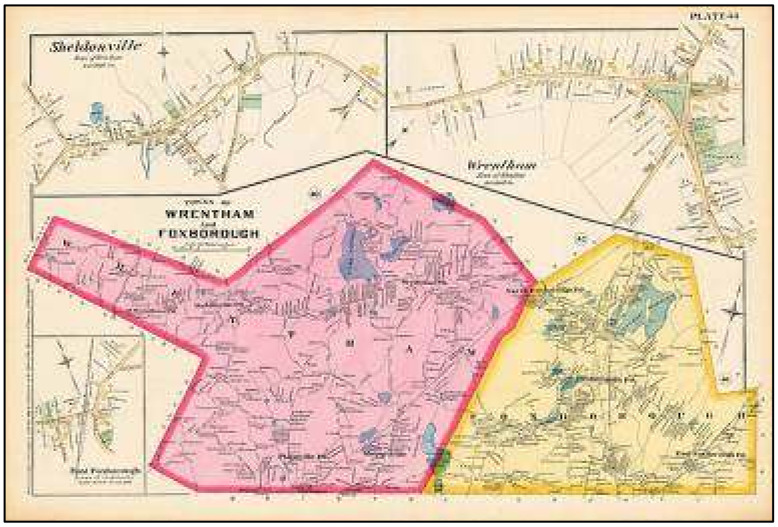
The idea, it seems, wasn't a new one. "The Underground River of New England," Engineering Magazine, an Industrial Review, October 1896 to March 1897, reported the discovery of a stream adequate to "supply all central New England for all time," a revelation made by a certain Professor Denton while searching for a supply of water pure enough to bleach the material for fine summer hats. Engineering Magazine adds,

> *Not far from the time that this river was discovered a large bleachery in Providence drove a well which yielded a never failing supply of very pure water, doubtless from the same source as that of the water supply of Lowell. The New Haven & Hartford railroad have struck the stream by wells at Pawtucket. The water is said to be better than ordinary spring water, and admirably fitted for use in steam boilers.*

The Journal of Commerce, September 26, 1896, provided additional details.

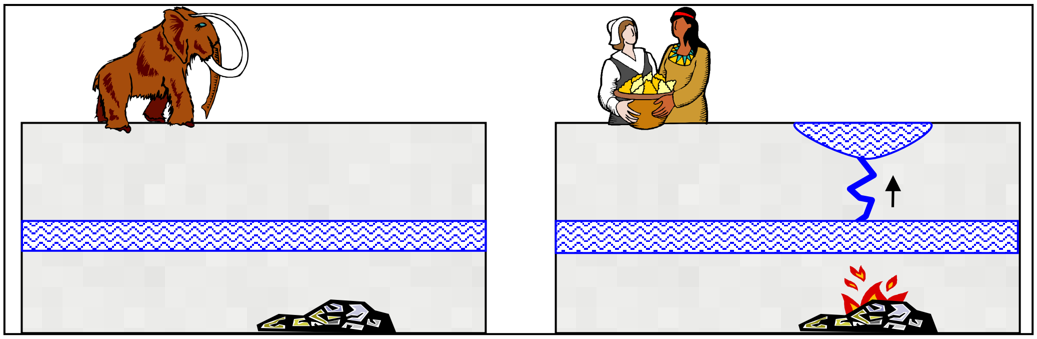
> *Witches' pond was so named years ago, on account of the many peculiar noises heard there. At intervals there were distinct rumblings beneath the surface. Superstitious persons were alarmed, and afraid to go near it. People who had no fear of ghosts watched the action of the water with interest. They always found the water icy-cold in summer, and it ever rolled and boiled. A water-pail would not cover the largest bubbles.*
>
> *The pond covers fifteen acres, and in winter ice forms there long before there are signs of ice on other ponds. Ice six inches thick forms on Witches' pond to every inch of ice on other ponds in the vicinity in the same length of time. Only a few years ago four men who were fishing through the ice narrowly escaped losing their lives. There was a sudden upheaval while the men were on the pond, and ice fourteen inches in thickness, that covered the peculiar lake, was thrown about. The men, having heard the internal rumblings, took warning and reached the shore just in time to avoid being precipitated into the boiling pond. Lily-pad roots as large as one's arm were brought to the surface at the same time.*

E. Robinson's "Map of Wrentham & Foxborough Massachusetts" (1888) shows Witches' Pond at the bottom, center.



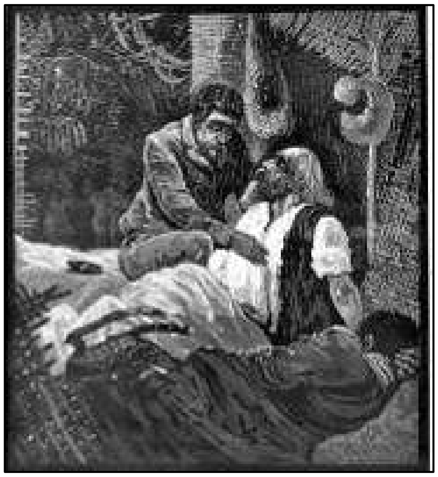
> *Professor Denton heard several stories about the pond, and out of curiosity made an investigation into the cause of the great boiling of the water which occurred at intervals. He tried to take soundings, but in several places he was unable to find the pond's bottom. Gases were detected rising from the pond, and he was led to believe that they issued from some distance below the surface. The water's remaining pure proved to him that the pond had an outlet as well as a source, and, as it was not visible, the investigation was all the more interesting.*
>
> *Pipes were driven about the well, and coal and blue clay were brought to the surface. Over one hundred feet below the level the pipe struck a ledge, and, after drilling the ledge on the south side of the pond, water was found. The water, when examined, was found to be purer than any other found in New England. Several wells were driven, and Professor Denton came to the conclusion that Witches' pond was an outlet for an underground river. It was when he told of his discovery that people laughed at him.*
>
> *The river located was one hundred and ten feet below the level. Above it was a covering of hard pan, and the bottom, twenty feet below the covering, was of rock. Professor Denton was of the opinion that there was no Witches' pond until there was an upheaval of the earth years ago, when the shelving rocks under and over the torrent were torn away. Aided by gases from the coal and other substances in the earth, a rent was torn, through which the water made its way to the surface.*

We'll pause to illustrate the process.



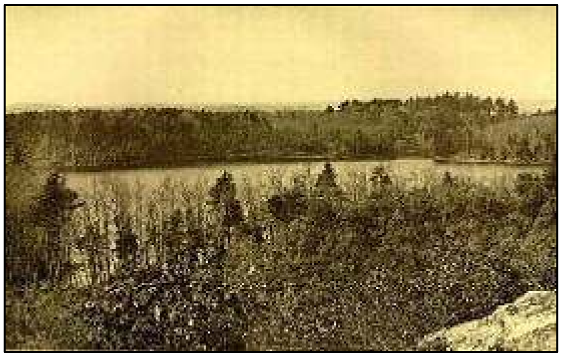
The streams in the vicinity of Foxboro are from a different watershed. The underground river is believed to come from a glacial spring in the White Mountains of New Hampshire, or beyond. It is known that the city of Lowell struck the river only a few years ago, and from that day to this has had a fine supply of water. At the time the Lowell wells were driven no one had heard of the river flowing under New England from north to south. The underground current has been followed by wells through Attleboro, Dodgeville, and Hebronville to Lebanon, where it swerves to the west and passes under Pawtucket falls on the Blackstone River, thence through Pawtucket southwesterly and under Providence, Cranston, Warwick, East Greenwich, and Wickford into North Kingston, and into the sea near Hazard's ledge.

That Professor Denton was being quoted speaks for his legacy, as he'd died 13 years earlier after contracting jungle fever on a trip to New Guinea. His death was extensively noted in the press, the illustration "Death of Professor William Denton, Argus Expedition, 1883."



While by no measure was Denton a discoverer of anything, the 1901 Engineering Index, Association of Engineering Societies, deemed him more.

> *River, Subterranean -- An Underground River. Remarkable subterranean stream of pure water flowing from the White Mountains, first discovered by the late Prof. Denton.*



The White Mountain source indeed had its respected advocates, literarily respected, that is. While Henry David Thoreau, author of Walden, or Life in the Woods (1849), is today revered as a naturalist, the fact is that he was fooled by Walden Pond. Surely some of the water, he deduced, must come from a distant locale.

Excerpted from Man and Nature, December 1971

> *Those who wondered why Walden does not seem to rise and fall with local weather long ago concluded that the source of Walden's water lay somewhere outside this locality. This theory has been strengthened by the facts that has no inlet, and is fed by springs whose source no man can see, and also by the common opinion that the slopes around it make a watershed too small to supply so large and deep a pond.*
>
> *Tales are told around town of the hole in the bottom of and the stream that comes through it, connected perhaps to a river that is rumored to run underground from somewhere in the White Mountains, perhaps Lake Winnipesaukee, southward to Cape Cod.*
>
> *Even though Thoreau lived by the pond for two years and visited it many more, he knew little about the matter, summing up what he did know in his book, "The pond rises and falls, but whether regularly or not, or within what period, nobody knows, though, as usual, many pretend to know."*
>
> *He wrote (Journal, August 27, 1852) that "the watershed by the surrounding hills is insignificant in amount," and suggested that the slow rises and falls of Walden were due to changes in the amount supplied by the deep springs fed from some unknown source.*

Although the writer was misled hydrologically, he recognized in much-broader context the analogy between the classical Greek underground rivers the American experience. From Thoreau's Walking (1861),

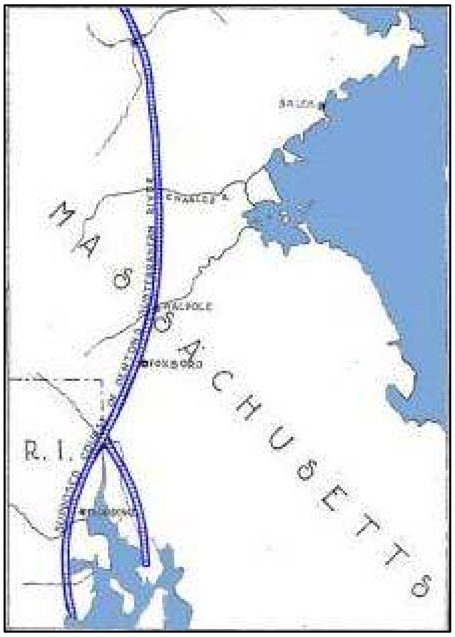
> *We go eastward to realize history and study the works of art and literature, retracing the steps of the race; we go westward as into the future, with a spirit of enterprise and adventure. The Atlantic is a Lethean stream, in our passage over which we have had an opportunity to forget the Old World and its institutions. If we do not succeed this time, there is perhaps one more chance for the race left before it arrives on the banks of the Styx; and that is in the Lethe of the Pacific, which is three times as wide.*

But back to Prof. Denton's river; it kept being re-reported. From the Oswego Daily Palladium, April 15, 1902,

> *Underground Stream Said to Run under New England States according to Theory of Professor Denton, the Mad Torrent Rushes Far Under the Earth from New Hampshire to Rhode Island.*
>
> *A law suite recently argued here before the Norfolk superior court of Massachusetts has revived interest in the theory that the people of the New England states are living on a crust of earth from 80 to 120 feet in thickness, beneath which there is a rushing torrent of water that makes its way from the White mountains in New Hampshire to Narragansett bay.*
>
> *The case in which talk about the underground river theory was brought up was that of Hollingsworth and Vose against the Foxboro Water Supply district. The plaintiffs claimed that the town of Foxboro had been taking water from a privilege that belongs to them. Foxboro denied the allegation.*

> *An effort was made to prove that Foxboro was taking its water from the Neponset River, of which the plaintiffs have full control. It was said that the peppermint was poured upon the surface of the Neponset in order to establish the case, it being contended that if the water sowed any signs of the essence when drawn from faucets in different places it would prove conclusively that the water was being taken from the Neponset River. No trace was found of peppermint, however.*
>
> *Of Course the Foxboro people were delighted with the result of test, but another experiment was made. It is said that a mammoth steam pump was erected near one of the wells, from which the Foxboro district obtains water, and the pump was put to severe test, pumping thousands of gallons of water every hour. Notwithstanding this, Foxboro got its usual supply of water with the same heavy pressure.*
>
> *The belief in the underground river owes its being to one Professor Denton, who used to deliver popular lectures throughout New England, his favorite theme being geology. Denton was a clever man who had evidently studies his subject earnestly. He was a convincing speaker. He could hold the attention of his hearers to the close of the lecture and in any town where he had once appeared he always found it easy to secure a re-engagement. He had a number of startling theories to expound, one of which related to a vast underground stream rising among the White Mountains and flowing southward.*

Professor Denton's map, we show on the right. As we've done before, the blue is our addition for clarity.



> *Denton traced the course of this river from near the New Hampshire line down through the state of Massachusetts to the Rhode Island border, where, he declared, the stream separated, forming a Y, one branch of which passed down the eastern side of the Providence River and the other to the west of it. His underground river crossed, he thought, though the deep underneath it, the Blackstone at Providence Falls, one of its branches running beneath the Seekonk River to an embouchure into the bay, the other arm proceeding down the western shore, crossing under the Pawtucket and two or three smaller streams and finally into Narragansett Bay near Wickford.*

While Professor Denton made no such assertion, the map shows the route just a bit west of the blue dashed line of Chapter 81 that's said to water Long Island.

> *This theory led the marvelous torrents underneath the town of Foxboro, where Denton claimed it comes closest to the surface, in fact where it finds an outlet in Which Pond. This idea is substantiated by the men of Foxboro who have tried to find the bottom of Which Pond. They have never succeeded, but startling tales are told of mysterious roarings below the surface. These roarings or explosions of gasses are followed by great commotions on the pond's surface. During these upheavals, report has it that lily pads as large as a man's thigh have been thrown up to the shore. In the icy water of the pond lurk mammoth pickerel.*

The March 2, 1902, St. Louis Republic, "New England's Mysterious River" provided additional detail.

> *Prof. Denton, Formerly of Harvard, Claims to have Traced an Underground Channel.*

Again, we must ask ourselves, what is the Professor's affiliation?

> *Is there danger of the earth's surface giving way and throwing thousands of persons and houses into the deep raving through which the river flows?*

A suggestion of danger never hurts newspaper sales.

> *Fish with no eyes have been found in the pond.*

This one's but a fabrication.

> *The entire distance of the course of the underground stream follows a natural channel made by the meeting of two ledges, one sloping from west to east and one sloping from east to west, and coming into contact from 80 to 120 feet below the surface of the earth.*

While it's bogus stratigraphy, as Professor Denton knew well, detail can sell a vague idea.

> *Professor Denton was of the idea the course was that of a flow during the glacial period, and that changes of the earth's surface in time caused the raving to become filled, still leaving the river to flow through its natural conduit.*

As the region had indeed been glaciated, the scenario is at least plausible and seems not to preclude the "natural conduit" being filled with porous media. Denton would surely have been aware of common aquifers, but deemed that "underground river" portrayed a more vivid picture.

The New York Times of February 6, 1902, ran a briefer version, adding, "Prof. Denton, who was at Harvard years ago."

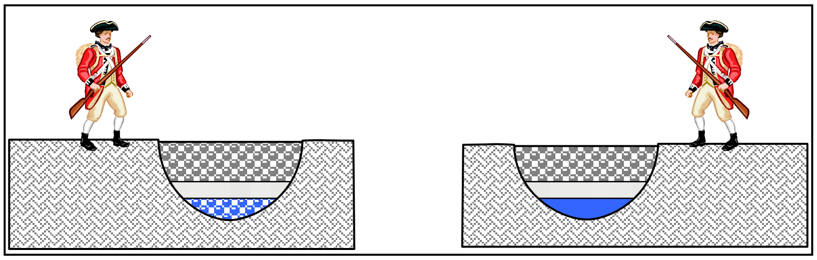
What no reporter makes clear is the source of Denton's opinion. None of his many books entertain the subject of geohydrology. His lectures were widely summarized in the news, but no archive indicates such a topic. As he indeed expounded regarding the glacial record, however, it does seem probable that New England stratigraphy would have been mentioned.

The scenario most likely is that the Professor's passing remarks -- eloquently presented, we may be sure -- had assumed a mantle of authority.

The McKean Democrat, March 31, 1893, printed the following.

> *Rev. Dr. Foster of Boston in his weekly letter to the Chicago Advance, states that there are reasons to suppose that there is an underground river about a hundred feet below ground, running through Massachusetts and Providence and emptying into the sea. It is supposed that this river, whose waters are ice-cold and exceedingly pure, starts from the White Mountain region and finds its way through an old ravine dug my a glacier, and then filled with gravel and covered with hard-pan. Water of that ice-cold quality and of great abundance has been found at about the same depth in Providence, in Foxboro and two miles west of Lowell. In two of these cases it is certain that there is a cavity scarcely a hundred feet below ground, through which the water flows, for in each case the drill dropped from ten to twenty feet after reaching water and then struck a ledge. If there is this stream of pure cold water traversing our Commonwealth, it will be hard to over-estimate its value to Eastern Massachusetts in years to move, to whom the problem or a pure water supply is one of great difficulty, but of vital importance.*

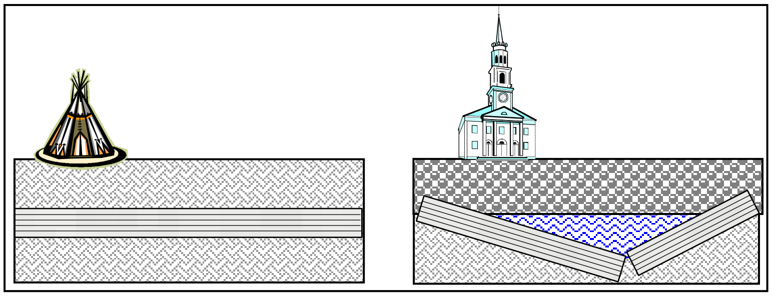
The Rev. Doctor isn't, in fact, too sure of how the underground river works. It's a gravely artesian aquifer. It's a perforatable cavity. In any case, it's an important discovery.



"Talk of a Subterranean River, Long Alleged to Exist in New England, Revived by a Case in Court," Brooklyn Eagle, February 23, 1902, however, wasn't impressed with the story's source.

> *The subterranean river was discovered by one "Professor" Denton. Twenty of twenty-five years ago one "Professor" Denton was wont to deliver popular lectures throughout New England, his favorite theme being geology. He was not, as some have claimed a Harvard professor -- in fact, it is doubtful if he took his title from connection with the faculty of any college -- he was just a "professor."*
>
> *Denton was a clever man who had evidently studied a good deal in his favorite science, and who was an earnest and convincing speaker... He had quite a number of rather startling theories to expound -- theories which none of the recognized authorities had ever promulgated, but which he argued with such plausibility that they seemed the veriest assertions of fact.*
>
> *One of these theories pertained to a vast subterranean stream, rising among the eternal snows of the White Mountains and flowing southward toward Narragansett Bay... He declared that is was a great natural trough at an average depth of 80 to 129 feet beneath the surface, caused by the meeting of two layers of rock, one dipping from east to west, the other from west to east.*

Again we'll pause for illustration.



> *Professor Denton's theory led to the marvelous torrent underneath the Town of Foxboro, where, he claimed, it comes closest to the surface; in fact, where it finds an outlet into Which Pond.*
>
> *Now, right here comes in the severest test to my credulity of the Denton subterranean river water supply hypothesis. If this wondrous river really comes to the surface in Witch Pond and the town is using any part of its water for domestic purposes, why should it have gone to the expense and labor of driving wells close to the Walpole line? Why not have set up a pumping station on the shores of Witch Pond and pumped those icy, pure and inexhaustible floods into the town mains?*

The article then recalls Foxboro's contention that its water supply was derived from groundwater independent of local streamflow vs. the counter claim of water integral with surface flow and thus subject to the same rules of use. (We pursued this legal distinction in Chapter 63, The Law of Subterranean Streams.)

The Eagle summarizes the opinions of the expert witnesses -- this time bona fide Harvard and MIT faculty -- who debated the specifics, but concurred that Foxboro sits on a stratified aquifer system of regional breadth. Foxboro's attorney, the Eagle notes, judiciously avoided Professor Denton's theory, which would have been evidence in the town's favor. The case was resolved by negotiation.

It's just so hard to keep good copy down. "The Water Supply of Nashua, N.H." in the December 1902 Journal of the New England Water Works Association by Horace G. Holden illustrates how Denton's thoughts made it into a respected engineering journal.

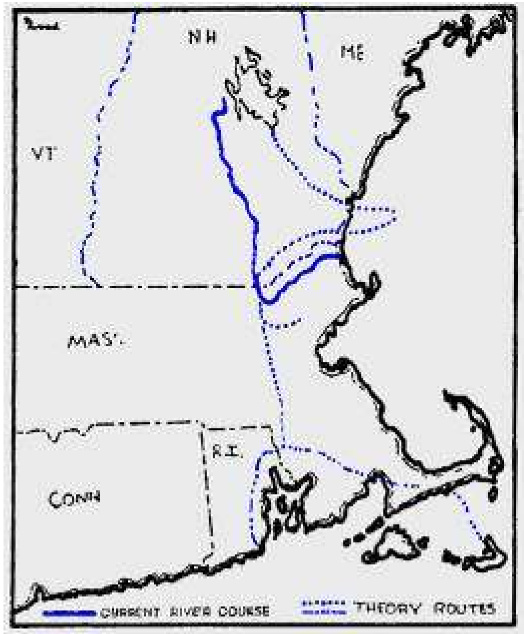
> *Professor Sedgwick informs me that this change of temperature is probably caused by the water flowing underground from a long distance, and if his theory is correct (as I have no reason to doubt) it may be possible that this water comes from a continuation of the*

> *underground river which Professor Denton, formerly of Harvard College, is said to have traced from Narragansett Bay to the New Hampshire state line, according to an item which was published in February 1902, in several Massachusetts papers.*

The New Hampshire reference wuld be to the boulder gorge discussed in Chapter 41, but Denton would have needed to do little but listen to local lore, of which "Mystery of Underground River Flowing Through Area," Nashua (New Hampshire) Telegraph, January 17, 1974, provides a summary.

> *A river, trapped 800 to 1,000 feet below the earth's surface, running from the White Mountains in New Hampshire to Cape Cod and Rhode Island, was once the chief source of water for Lowell, Mass., and numerous other communities along its path.*
>
> *Sounds Incredible? Only if you are a non-believer in what might have happened during the Ice Age, and if you believe that Witches' Pond in Foxboro, Mass., is merely spring -fed.*
>
> *It was in that community, located about half way between Boston, Mass., and Providence, R.I., that stories gained most recognition in the 1800s of the body of water free of a visible outlet, and without a visible inlet.*
>
> *The river was traced in that time by wells form Lowell, through Attleboro, Mass., under Pawtucket, R.I., Cranston and North Kingston, RI, eventually to the ocean.*
>
> *The most elaborate of all theories was that it was the true course of the pre-glacial Merrimack River. The thought was that before the glaciers, huge valleys extended from the White Mountains, following a somewhat winding course to Rhode Island and Capt Cod.*
>
> *These valleys were filled in and the present topography along these routes is chiefly the product of a period of intense erosion followed by one of dominant deposition. The theory is, and some believe, that Lake Winnipesaukee empties at, or near, Alton Bay, that the water rushes downward for a distance of about 800 feet below the earth's surface, then levels off and flows in what is now known as the Farmington River Valley, a southeast course to the sea.*
>
> *The river was said to travel beneath the ocean floor for a short distance, then swing back toward Rye, Exeter, Derry, eventually passing through Nashua along approximately the same course the river now follows in a southerly direction.*
>
> *At Lowell the river turns east, northeast, but it is believed that at one time made a much wider sweep to the south side of the city, to Billerica before making a turn eastward.*
>
> *Another theory advanced is that the river follows a winding course, about 200 miles from Wolfeboro, N.H., on the shore of Winnipesaukee, to Cape Cod, where it supposedly supplies groundwater to wells on the Cape.*
>
> *A side theory of that, is that the fabled underground river flowing under Foxboro, divides in the area of Pawtucket, with one branch flowing due south, and the other going in the easterly direction of Hyannis, Mass., then southward under the ocean to Martha's Vineyard.*
>
> *One theory states that the river flows about 600 feet below the surface of the ground from Winnipesaukee. It supposedly twists out to sea and back, then splits into two branches and returns to one again. In places it is reportedly 20 miles wide, truly an American or rivers.*

The Telegraph's rendition of these layouts is shown to the right.



As for what the locals have since come to believe, the feature in the Telegraph brings us somewhat up to date.

> *U.S. Geological Survey, Department of the Interior, has made extensive studies in the area of Nashua and Lowell, but admits that beyond this point to the South, the path of the pre-glacial Merrimack is sketchy.*
>
> *"If the fable were true," states a report from Geological Survey, "Lake Winnipesaukee would indeed be in danger. The total volume of water in this huge lake at the present is about 14,600 million cubic feet. If the underground river were 20 miles wide, as reported in legends, the lake would drain in three hours."*
>
> *John Cotton, of Geological Survey in Concord, explains that the legend of the underground river must be just that -- a legend, and at best a theory.*
>
> *"The most spectacular examples of a true underground river," he explains, "are found in areas where limestone rock exists, also in volcanic terrain."*
>
> *"We don't have the extensive limestone covering that they have in Virginia," he said. "This is the source of water we hit when we drill a well," he said. "The cracks are very narrow, and not much water flows. The idea of an underground river, as such, is entirely impossible."*
>
> *"The theory just can't be so," he says of the underground river. "The tunnel has to be in hard rock, and the only place you can have that is in limestone terrain. We have none."*
>
> *As far as Witches' Pond having no inlet or outlet, Cotton explains there are many ponds of this sort, most of which are spring fed. The water merely filters through the soil, and some is lost to evaporation.*
>
> *But the people of Foxboro are not so sure. They are determined there is an underground river feeding their Witches' Pond.*
>
> *Even after 100 years of yarn-spinning about the infamous flow of water beneath the earth's surface, the residents of that town are still exploring the area in hopes of tapping a huge, unlimited source of water.*

Conclusion

There is, of course, no such New England underground river. There was, however, an influential "professor" of modern science (plus a few other causes) whose flamboyant advocacy lent enduring credence to such a watercourse.

CHAPTER 84
UNDERGROUND RIVERS OF GOLD

A few economic topics in our underground river journey thus far:

Reference	Chapter
Charon's obols	1
Adam Smith	24
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Yugoslavian national budget	58

Victorian historian Thomas Carlyle viewed economics as "the dismal science." Had Carlisle foreseen the rise of the subjective social sciences, he might have found more-deserving candidates, but we'll agree that, as applied to underground rivers, economic scholarship has indeed been somewhat dismal.

But there is one economic topic that's not dismal to anyone -- the study of gold.

As observed in Rudyard Kipling's "Robin Goodfellow -- His Friends," McClure's Magazine, October 1906,

> *We Jews know how gold moves with the seasons, and the crops, and the winds; circling and looping and rising and sinking away like a river -- a wonderful underground river*

Gold and underground rivers indeed circulate as one through history, literature, science and even our psyche.

In this chapter we will review the references to gold in previous chapters, add a few more, and in so doing, prepare for the chapters ahead, chapters that focus on our own beliefs.

Gold Fever

Underground waters -- we're forced to concede -- don't elicit much excitement in the market place. There may be money to be made, buying and selling what flows below, but most of us would rather invest in what transpires in daylight.

What draws our attention is gold -- gold dust, golden nuggets, golden artifacts, it hardly matters. Mention 24 carets and the financial crowd appears.

Cyrus Teed, the hollow-world visionary of Chapter 14, knew how to win disciples.

> *The earth shell consists of 17 layers of which the outermost seven are metallic, the golden layer having the greatest radius.*

Why the earth's outer shell is of gold -- as opposed to, say, nickel -- the Koreshens didn't seem to wonder; it stood to reason that revealed truth would be gold plated.

Among underground river proponents, Teed was by no means alone in such embellishment.

From Adam Seaborn's Symzonia of that same chapter,

> *Gold is abundant in the beds of rivers near the mountains, but it is not esteemed, because of its softness and great weight. It is chiefly employed in the fastening of their vessels, in place of iron, which is very rare, and much valued for its strength, and fitness for all the purposes of agriculture and mechanics.*

Given the common attribution that Seaborn was Symmes, himself, the meaning is clear: Go to the lands below, you Yankee merchantmen, where you can barter your iron for gold.

The Adventurous Simplicissimus (1669), Chapter 16, Underground Rivers in English Fiction, informs us that in the subterranean kingdom,

> *There are numberless silver mines within its borders; the sand of its rivers is colored by gold, and its coasts are paved with pearl oysters of the finest water.*

The stranger of Bret Harte's The Legend of Monte Del Diablo (1867) leads Father Jose into the earth.

> *"Step under the shadow of my plume," said the stranger.*
>
> *Father José stepped beside him and they instantly sank through the earth.*
>
> *When he opened his eyes, which had remained closed in prayerful meditation during his rapid descent, he found himself in a vast vault, bespangled overhead with luminous points like the starred firmament. It was also lighted by a yellow glow that seemed to proceed from a mighty sea or lake that occupied the centre of the chamber. Around this subterranean sea dusky figures flitted, bearing ladles filled with the yellow fluid, which they had replenished from its depths. From this lake diverging streams of the same mysterious flood penetrated like mighty rivers the cavernous distance. As they walked by the banks of this glittering Styx, Father José perceived how the liquid stream at certain places became solid. The ground was strewn with glittering flakes. One of these the Padre picked up and curiously examined. It was virgin gold.*

We came upon lesser works in Chapters 19-23, fiction for boys and girls.

Tom Swift in the City of Gold (1912) by Victor Appleton
Desert Gold (1913) by Zane Grey
"River of Gold" (1951), the Roy Rogers comic book adventure
"Cloud City of Gold" (1967), the Spider-Man TV series
Inca Gold (1994) by Clive Cussler

And those were just the works with "gold" in the title. Perusing the content,

The Wonderful Adventure on the Yukon Tributary (1898) by W.M. Graydon, in which Quin traverses an underground river to a valley of gold.
The Three Young Ranchmen, or Daring Adventures in the Great West (1901) by Capt. Ralph Bonehill, in which the boys discover of a gold mine while exploring an underground river.
The Sunless City (1905) by William Miller in which Flin pilots his submarine through a hole lined with gold.
Under the Andes (1914) by Rex Stout, with the "golden, flaming urns."
"The Flying Legion," All-Story, November 15, 1919, in which the Legionaries discover a pyramid of solid gold and leap into an underground river.
Polly of Polly of Pebbly Pit (1922) by Lillian Elizabeth Roy, deducing,

> *The subterranean stream we found in there. Some big upheaval changed its outlet, or maybe this gold vein runs clean through and Montresor's claim is staked opposite this side.*

The Mystery of the Piper's Ghost (1954) by Zillah Macdonald, in which the boys search for a gold mine below the lake.
Callaghen (1972) by Louis L'Amour, advertized as following an "underground river of gold."

Golden threads woven into the fabric of fantasies makes the plot more vivid, the readers more engaged, and not surprisingly, the royalties more lucrative.

But gold-laden underground rivers extend far beyond popular fiction.

Lode Gold

We saw in Chapter 45, Subterranean Geophysics, that the effluent of a sub-oceanic black smoker bears sulfur, copper, zinc, iron, and -- not to our surprise -- gold, but we needn't limit the gold association to waters under the sea.

To understand the presence of gold in rivers beneath our feet, we need to understand what was there before the watercourse came to be.

Elemental gold is naturally present in much of the earth's crust, but only very diffusely, about 5 milligrams/ton or rock, and tightly bound within that rock. To free the gold, volcanic temperatures are what's needed, that plus a little sulfur.

The heat and pressure of molten magma is enough to cause gold molecules to geochemically react with adjacent elements -- sulfur being the most common partner-- to form water-soluble compounds.

As the magma cools, the volatile substances separate, but the once-inert elemental gold -- along with silicon, iron and sulfur -- is now in a hydrothermal solution which continues to force its way into the surrounding rock.

As the plume further cools and depressurizes, still deep underground, solutes begin to precipitate. Growth of coarse minerals requires stable conditions in which large crystals can grow over an extended period. Gold can emerge in crystalline shapes including dendrites, leaf, deformed octahedrons and cubes, but unlike for quartz, such conditions are rarely satisfied. More often the gold emerges as microscopically-agglomerated particles. The resultant masses may have a form suggesting that it once was melted, but that's almost never the case.

Such concentrations are known as "lode" or "hard rock" veins. A lode is rarely the result of a single igneous upwelling, but rather is the product of eons of geothermal intrusions, often through a history of repeated fault slip and fluid flow events aligned by a persistent structure which repeatedly directs the slippage.

Lodes can form at the meeting of different rock types, as water circulates more readily along the interface than through the solid rock itself. Where a zone of fractured rock develops with no strong single fault shear, a series of small parallel veins may develop.

The precipitate's yet embedded in rock, but the gold's now more recognizable.

> The gold is concentrated along a one-time geothermal flow path that, by virtue of surficial discontinuities, may be discernable to a geologist.
>
> The gold is embedded among geochemically-akin minerals -- quartz and sulfides such as pyrite, galena and arsenopyrite being common -- that may be known to a prospector.
>
> The gold's now particulate, flakes identifiable to the human eye.

Mining of lode veins involves shafts, pits and other means of penetrating the deposit to extract the ore. Water can be cause for mining distress, as noted in "Find Cave Full of Gold," Hickman Courier, November 15, 1901.

> *What is probably the greatest mining strike ever made in this or any other camp was made Oct 22 in the famous Elkton mine at Cripple Creek. At a depth of 700 feet in a level run to the south from the shaft there has been opened up a veritable cave containing fabulous wealth never before in the history of the Cripple Creek district has a find of such magnitude been chronicled and it is certainly the first time a strike has been made where experts were all in doubt as to whether the body encountered will prove to be the mother lode of Raven Hill or a volcanic chimney.*
>
> *This cave was originally broken into in January last but the next round of shots put in following its discovery tapped an immense underground river or lake permitting the water to enter the*

> *level. The water entered through the vent with tremendous velocity forcing the miners to hasten to the surface to avoid being engulfed in the flood. Within a few hours the workings of the mine up to and including the 700 foot level were submerged.*

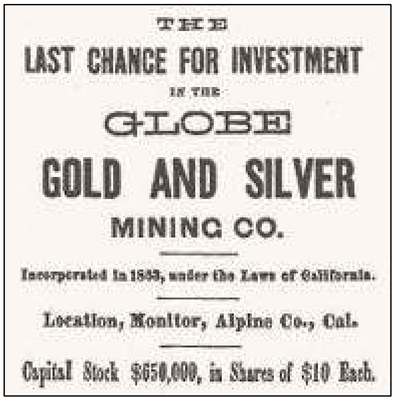
Gold fever at Cripple Creek would endure and so would the pesky subsurface stream. "Cripple Creek Digs for Comeback," Business Week, December 23, 1939, reported the $2,000,000 tunnel system necessary to "drain off underground streams."

But let us not dwell on Cripple Creek, portraying underground water in such bad light. We who journey on underground rivers would rather see our subject more positively.

An advertisement in the October 30, 1869, Prairie Farmer illustrates the metaphor of the underground river of gold.

> *We have before us a beautiful specimen of ore from the Globe Mine, and we learn that the indications are rapidly improving as the miners approach the center of the great Mineral Belt that stretches along the Garson River like a subterranean stream of the precious metals -- arrested in the mountains and petrified in their channels.*

The Globe Mine didn't, in fact, measure up to its prospectus, but it did prove to be a productive source of copper.



THE
LAST CHANCE FOR INVESTMENT
IN THE
GLOBE
GOLD AND SILVER
MINING CO.

Incorporated in 1863, under the Laws of California.

Location, Monitor, Alpine Co., Cal.

Capital Stock $650,000, in Shares of $10 Each.

Placer Gold

To mine a lode's bounty, we must excavate mountains of earth and who wants to move all that muck?

Who would not prefer to pluck gold nuggets -- ones that have had millennia to agglomerate, preferably -- from the surface? Or if we simply must, wade a river underground and with the help of a flashlight, gather the glittering mineral lining the streambed?

This, then, brings us to "placer" or "alluvial" gold, veins formed in present and past watercourses.

Chemical oxidation and mechanical weathering eventually break down the stone matrix of a lode vein, exposing the encased minerals to the tractive sweep of runoff, first as rill erosion and then as bed-load in streams. Because gold is relatively heavy, its particles are more difficult to wash downstream and thus concentrate in alluvial deposits on the inside of river bends, in abandoned meanders, and anywhere else where sediment accumulates.

Placer gold is reasonably accessible to even the casual miner.

> With time, the particles are welded by water action into larger flakes.
>
> Placer gold is associated with gravel deposits, both current and abandoned.
>
> The gravel can be immediately panned, or given the proximate water course, sluiced, reducing the human toil.

The world's great gold rushes -- that of the California 49ers being the most famous -- have been foot races to stake placer claims. There's money to be quickly made, and of course, as quickly squandered.

Following are a few popular-press associations of placer gold to rivers beneath the land, not necessarily geologically accurate, but sufficient to the get gold pans swishing.

From "The Gold Placers of the West," Omaha Daily Bee, September 9, 1881,

> *In some instances the material of which these underground river beds are formed carries gold in considerable quantities, and, in California especially, the superincumbent mountains are also frequently rich placers.*

From "A Gold Miner's Stories, Reminiscences of the Days of '57 and Afterwards," Springfield Daily Republic, December 31, 1887.

> *At a camp in Calaveras County, the miners for years ran their mud and stone from the sluice's mouth into a crack in the earth. It never filled up. The gurgling of running water could be beard in it. During one summer, while "waiting for water" (one third of our time in the mines was passed in this way), the "boys" concluded to explore this mysterious underground region. They built a small boat for the purpose, lowered it down, and Johnny Ward, who had volunteered to navigate this underground river, after it. He did go a little way, as far as he dared, but the river disappeared amid low overhanging rocks and darkness, and Johnny was hauled up again and the boat left to rot.*

The location is that of Samuel Clemens' first literary success, the 1867 tall-tale, "The Celebrated Jumping Frog of Calaveras County."

From Getting Gold, a Practical Treatise for Prospectors, Miners, and Students (1896) by J.C.F. Johnson,

> *On an alluvial lead the object of every one is to "get on the gutter," that is, to reach the lowest part of the old underground watercourse, through which for centuries the gold may have been accretionising from the percolation of the mineral-impregnated water.*

We're reluctant to include Lost Cities of North & Central America (1992) as news, but regarding placer deposition, author David Hatcher Childress has the correct idea.

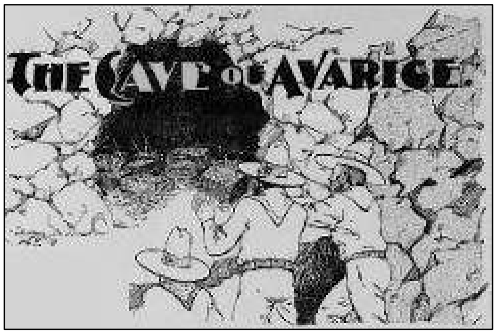
> *Underground rivers such as these are known for a fact to exist, and that gold would exist in the sand along beaches along the river is also natural occurrence. Since gold is indestructible and quite heavy metal, it tends to wash down streams and rivers and collect in pools and other areas... Almost all sand contains a little gold, but it is sand with a high percentage of gold that makes processing of the sane worthwhile. An underground river with beaches could have thousands, even millions, of years for gold to collect.*

Buried Treasures

To this point, we've been prospecting for nature's bounty, but even with placer veins, it's hard labor. It would be easier to stash that for which someone else has labored or quicker to make off with what someone else has stashed.

"The Cave of Avarice," San Francisco Call, April 3, 1898, is Poesque in its prose, if not in its artwork.

> *The church declares that the wicked shall be burned forever. If that be indeed true -- and no man has ever come back to deny it -- it behooves me to prepare. I have thought of the treasure I gained evilly. Should I restore it to those whence I had taken? But the lust for gold makes more crime than the lust for women.*

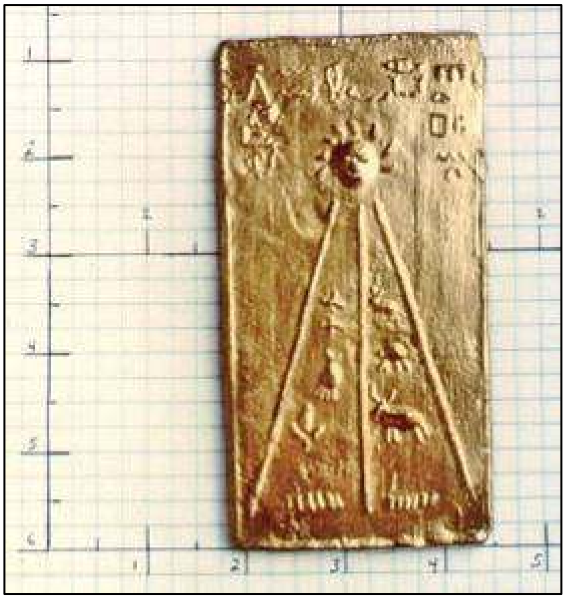


> *It has seemed to me, then, that I should put this treasure away where no man should find it. I know now my sin. I could not part with that which has cost me so much -- perhaps even my soul. To the cave of the underground river I had the casks carried. Then I had a wall built*

> *twenty rods from the cave entrance, and I walled the treasure there against the roar of the stream that sees no light.*

The looting of hidden caverns stocked with golden artifacts -- their origin being ancient Americans, aliens from other worlds, or even the divine -- is often impeded by underground rivers.

"Lizard People's Catacomb City Hunted," Los Angles Times, January 29, 1934, reveals the location of gold tablets, 120 by 35 centimeters, as measured remotely by what seems to have been a dowsing device wired for radio and X-rays. The map's in Chapter 86, The Rio San Buenaventura, with "GOLD" clearly labeled. For those planning to dig, however, a City of Los Angeles excavation permit will be required.



In 1982, Russell Burrows, so we're told, discovered a cave along the Little Wabash River in Illinois. In the cavern were golden objects of ancient Egyptian origin, an example of which is shown to the right. (We're just passing on what's said. We weren't there, ourselves, but anybody can see that it looks Egyptian.)

Burrows' personal disillusionment with the reception of his news, however, led him to dynamite the cave entrance in 1989.

In 1999, Wayne May, publishers of the magazine The Ancient American, got Burrows to disclose the location.

May's attempts to gain access, however, were blocked by water. Alas, May realized, the explosion had diverted an underground river into the underground complex.

Alas!

We should pause to note that the above picture is the sole graphic in this chapter. Rarer than gold artifacts found along underground rivers are photographs of such.

Our second artifact story is "Rich without Money," a cautionary tale in Architects of Fate, or Steps to Success and Power, a Book Designed to Inspire Youth to Character Building, Self-Culture and Noble Achievement (1897) by Orison Swett Marden.

> *In the year 1843 a rich miser lived in Padua, who was so mean and sordid that he would never give a cent to any person or object, and he was so afraid of the banks that he would not deposit with them, but would sit up nights with sword and pistol by him to guard his idol hoard. When his health gave way from anxiety and watching he built an underground treasure-chamber, so arranged that if any burglar ever entered, he would step upon a spring which would precipitate him into a subterranean river, where he could neither escape nor be heard. One night the miser went to his chest to see that all was right, when his foot touched the spring of the trap, and he was hurled into the deep, hidden stream.*

Here's another gold-and-underground-river story, one reviewed in the 1908 University of Texas Record.

> *From the Waters Under the Earth by Lynn Milam... is the story of a coward, a young college graduate who, while wandering in Peru in search of gold, falls into a cavern, is imprisoned for days, follows an underground river, writes an account of his experiences and encounters with*

> *indescribably hideous remnants of a human race, gradually loses his reason, consigns the diary to the underground river, and meets -- what fate?*

We'll deal with the geography of William Halliday's Adventure is Underground (1959) in Chapter 86, The Rio San Buenaventura, but here we'll mention that the particular subterranean river with black sand beaches was said to assay at 50 troy ounces/ton. In today's market ($1400/ounce), that's $77/kilogram of ore, not a bad return for hauling sand to the surface.

And a good yarn doesn't die, as evidenced by the leading line from the Los Angeles Times article of September 11, 2006,

> *River of Gold or Touch of Fever? A 1930s prospector said a Mojave peak hid waterborne ore. Some are chasing his dream.*

Potential investors can contact Larry Hahn, "who owns a military surplus store in Las Vegas."

We'll also note in Chapter 88, a June 27, 1990, Southern Utah News report of Montezuma's Aztec treasure being behind a "water trap" in the lower of the three ponds six miles north of Kanab.

When the boundary blurs between recognized fiction and proclaimed revelation, we can wonder what influenced what? Author Clive Cussler describes the literary process in a September 1996, The Writer interview.

> *I always start with the germ of a concept. I used to tramp around the deserts of Southern California looking for lost gold mines and ghost towns before I began writing about shipwrecks. There was a legend of an old mining engineer who went into a cave on a mountain and found a river flowing in a canyon under the mountain. One day, I read that a hydraulics engineer thought there was an underground river under Nevada that flowed out to Los Angeles. So, I thought, "There's the grain of the story, an underground river." Of course, I had to build it from there.*

The golden torch has been passed in like manner from the days of Charon.

Not all gold-and-underground-river stories are mine lore or adventure fiction, of course. As reported in "Secret, Flooded Moat Guards French Gold," Woodville Republican, March 17, 1928,

> *A fortress with a moat guards the gold of the bank of France. "Even American bankers admire it," say officials of the bank.*
>
> *Deep in the cellars of the last-built branch of the bank, in an old aristocratic palace, there is always an armed sentinel with orders to let no one but the chief director enter. The entrance to the strong room is a metal safe door seven feet thick. Inside the gold is stored in other -- supposedly burglar-proof -- boxes.*
>
> *The most, sixty feet deep, has a swift ten-foot flow of water in it, delivered from an underground river.*

American bankers were duly impressed because America's Fort Knox Bullion Depository is but a two-story building having no underground river for protection.

We cited The World Beneath the City (1959) by Robert Daley in Chapter 82, Alligators Below, but beneath the city, we also find treasure.

> *A great deal of money has been found in the sewers, particularly during the depression when WPA labor scraped out or rebuilt vast lengths of pipes on Manhattan's West Side. The current in New York's trunk mains is so swift that it will -- well, it will wash along a horse. The trunk mains, therefore, are self-cleansing. But the branch lines drop only a quarter inch per foot, an incline so slight that the sewage moves slowly at best, and not at all at worst.*
>
> *The sludge, which cakes on the bottom of branch mains, is what these desperately poor WPA workers were sent in to re- move. To their absolute delight they found that the sludge was impregnated with coins. Hundreds of them. Thousands of them.*

> *The regular procedure had been to chip loose slabs of sludge, load them into a pail, then yank on the rope attached to the pail, signaling topside that your pail was full. The men above would drag it out, empty it, and drop it down again. No one liked working in the sewers, but these were depression years and a man took what he could get. The crews alternated, four hours in the sewer, four hours outside emptying pails instead of filling them. A man outside felt himself an aristocrat, superior in every way to the moles under the street.*
>
> *The discovery of gold changed all that. A piece of sludge broke apart in a man's hand exposing a quarter. Immediately he dived for the pail he had just filled and began to crush slabs of sludge in his fingers. He found a dime, a penny, another quarter. He went through the pail a second time, dumping its content out and stomping on it until it was pulverized. More coins turned up. He began to yell excitedly. Other men began searching their pails. They, too, found coins.*
>
> *The men began to attack the sewer with frantic energy.*
>
> *When the next crew came to relieve them, they refused to go, shooing the others out of the tunnel. Soon the second crew, having discovered what was happening, clamored and fought to get down to the sludge.*
>
> *The WPA had struck a vein... that seemed as rich as the Klondike. Men staggered up to the street drunk with wealth, their pockets bulging with money. Gone were the previous social distinctions; the man in the sewer was a prospector (they called themselves "Klondikers"); the men who preferred outdoor work were fools.*
>
> *The West Side sewers became the most sought-after work in town. Soon the men instituted a share-the-profits plan such as countermen in diners employ, and each man went below with two pails, one for sludge, one for coins. The sludge was "klondiked" once in the sewer, then sent aloft where it was "reklondiked." All the money was kept in a neat pile beside the manhole, to be divided at the end of the day. All day the men took pleasure watching the pile grow (some attained a height of two or more feet) and toward quitting time they loved the way it glinted in the descending sun.*
>
> *Like other veins of gold, the one in the sewers gave out after a time. Sewer prospecting does not exist any more. The day of the "klondiker" is over.*

Yes, the days of klondiking seem to be over, but in the future we' will surely witness additional gold rushes involving underground rivers. The two seem to flow together.

Gold -- or at least coins of lesser value -- can be found at the underground stream outlet on the Indian Ladder Trail near Albany, New York.

Generalizing on such riches, we can probably say that more gold had been thrown into underground rivers by tourists than has been extracted by miners.

UNDERGROUND STREAM OUTLET

Bottled Gold

The economics:

> Municipal water typically costs less than 1 cent/gallon. At $4/gallon, gasoline is about 3 cents an ounce. At $1 for a 20-ounce bottle, bottled water costs 5 cents/ounce.
>
> In excess of $100 billion is spent each year on bottled water. Global gold production is valued roughly the same.

Mountain Top
premium
natural spring water

Why bother do dig for ore? we might ask, when we can more easily bottle its "mountain top mineral springs" surrogate not from mountain tops (Chapter 8, Subterranean Engines), but convienently beneath our feet.

Vitapress, a Hungarian company, discovered an "underground river" while drilling a well for its line of soft drinks. Water from the source, bottled under the name Szentkiralyi, is distributed throughout Europe.

> *From a depth of over 200 meters, originating in an underground river several millions of years old, our water travels through 15 layers of strata to develop its mineral composition and unique pure flavor.*

There are, of course, more-affordable options. Entrance to Cave Spring Cave, Cave Spring, Georgia, is just $1.00. It's not a "show cave," but it's clean and produces 100 liters/second, free for the taking to those with bottles. The water's been featured on Food Network's "Good Eats."

Cave Spring, 1908

ENTRANCE TO CAVE, CAVE SPRING, GA

Cave Spring, 1915

1st
Best Deal
1 Load
$1.00

Cave Spring today

A Marxist-Leninist-Maoist Perspective

We've focused on the acquisition of underground river gold, we admit, from a shamelessly capitalistic viewpoint. Find it and grab it. For the sake of fairness, however, the other side should be heard regarding the legitimately of such wealth.

暗河

To the right, àn hé, "underground river" in Mandarin, a product, it seems, of dialectical materialism. From Karst in China, Institute of Hydrogeology and Engineering Geology, Chinese Academy of Geological Science (1976),

The Masses Surveying Karst Water

> *Under the leadership of our great leader Chairman Mao and the Communist Party of China, the Chinese people have overthrown the three big mountains (imperialism, feudalism and bureaucrat-capitalism) and have established a socialist country under the dictatorship of the proletariat. Following Chairman Mao's revolutionary line, the broad masses of workers, peasants and soldiers, together with the scientific and technical personnel, have attained gratifying results in applying Marxism-Leninism-Mao Tsetung Thought to the fields of class struggle, struggle for production and scientific experiment, as well as in recognizing and remaking nature with the viewpoint of dialectical materialism.*
>
> *In the construction of water conservancy and hydro-electric projects, plants and mines, communication lines and engineering works for national defense, extensive investigations on karst have been carried out and new experiences on the utilization and transformation of karst accumulated. Particularly since the Great Proletarian Cultural Revolution and the movement to criticize Lin Piao and Confucius, great changes have taken place.*

The Democratic People's Republic of Korea honors the discoverers of underground rivers.

> *A mysterious-looking natural cavern and scenic underground spots were recently discovered in south and north Phyongan provinces. The newly-discovered cavern, which proved tens of thousands of years old, has some different aspects from other caverns. Stalagmites and stalactites of the Ryongmun and Paekryong caverns are large and beautiful, while those of the newly-discovered cavern are very fine, delicate and graceful... The water of the underground river and waterfall flows steadily at a fixed speed. Multitudes of stalactites and stalagmites surrounding them add beauty to their scenery. Secretary Kim Jong Il sent thanks to units which discovered the natural cavern and scenic underground spots.* -- Korean Central News Agency, April 18, 1979

Karst is manifestly real to those of the Party, but garnering wealth from underground rivers is a bourgeois error of thinking.

CHAPTER 85

DAYLIGHTING

This chapter presents the antithesis of the topic of Chapter 73, The Sinking of the Fleet, the reduction of urban streams to enclosed sewers.

"Daylighting" projects uncover and restore creeks, streams and rivers previously confined in underground conduits. Daylighting restores a part of the natural hydrologic cycle, reduces peak discharge rates, enhances environments; habitat and provides recreational facilities.

We'll look at several examples -- one Asian, the remainder, American -- once buried beneath the urban landscape, but subsequently returned (or in process of being returned) to the sunshine.

Cheonggyecheon River, Seoul, South Korea

The Cheonggyecheon River was a centerpiece of Seoul since the city was established 600 years ago. The river's 23 tributaries, often dry in the spring and fall and flooded during the summer, supplied the metropolis with drinking water for the next 500 years, while the Cheonggyecheon washed away the wastes.

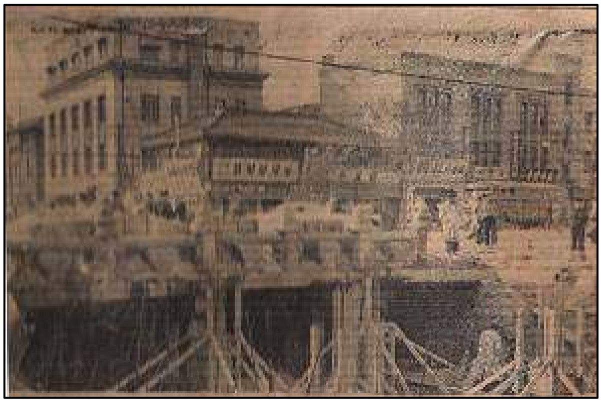
Beginning in the 1920s, the Japanese converted many of the tributaries into covered sewers and in 1935, they announced a plan to cover the river with an elevated railroad. Two years later, a small section was covered. In 1939, the plan was altered to cover the river with a motorway. In 1940, the plan was for a tram above and a subway below. Urban ambitions faded, however, with the war.

After World War II, South Korea developed plans to dredge the Chonggyecheon, but these plans were interrupted by the Korean War.

By the mid 1950s, the Chonggyecheon urban area was mired in poverty and filth, the legacy of colonialism and war. The open sewer in the city's center was an obstacle to the redevelopment and between 1955 and 1977, the river was at last covered. A freeway was built above the route between 1967 and 1971.

"Good Riddance…and yet -- 'Stream of Pure Ravine' Slowly Flowing Into Realm of Memories," Korean Republic, November 18, 1958, summarizes the fate.

> *One signpost in Seoul you can read with your eyes closed is Cheonggyecheon -- the Stream of the Pure Ravine. The deep, cloying whiff exuding from this muddy stream has been an odor that any Seoulite remembers from his days in primary school.*



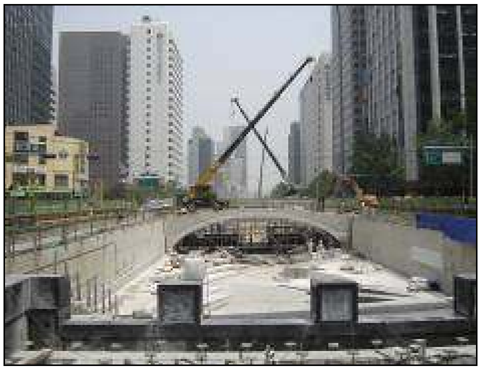
Enclosing the Cheonggyecheon, 1958

> *Soon, this odor-binding signpost with all its merits and demerits will be no more as the currently-progressing highway projects comes to an end. And, together with it will go the old, bent men who have predicted thousands of futures from thousands of palms along the stream. Also, the little boys with their scrawny hands who have had what they will sometimes remember as the best years of their livings, shining shoes for men leaning against the bridge railings.*

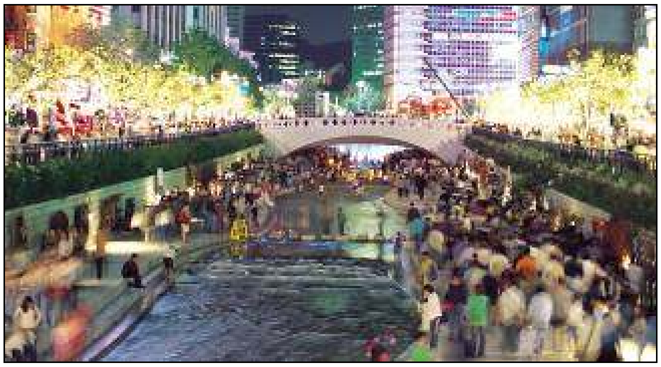
> *This will also mean the loss of a fairyland playground for urchins who "fished" for the fish there never were after a summer showed added a torrent to the dirty water and spirited its malodor away – or who sledded over it after it was coated with ice.*
>
> *All these will go by 1960 when the entire length of the Stream of the Pure Ravine – that has never been pure-- will be covered up as part of the City Plan.*

By 2000, the area was the most congested part of the South Korean capital, badly in need of revitalization. There could be no significant change as long as the freeway remained.

A master plan for stream restoration was adopted in 2003 and the freeway demolished. River reclamation began that same year and was completed in 2005.



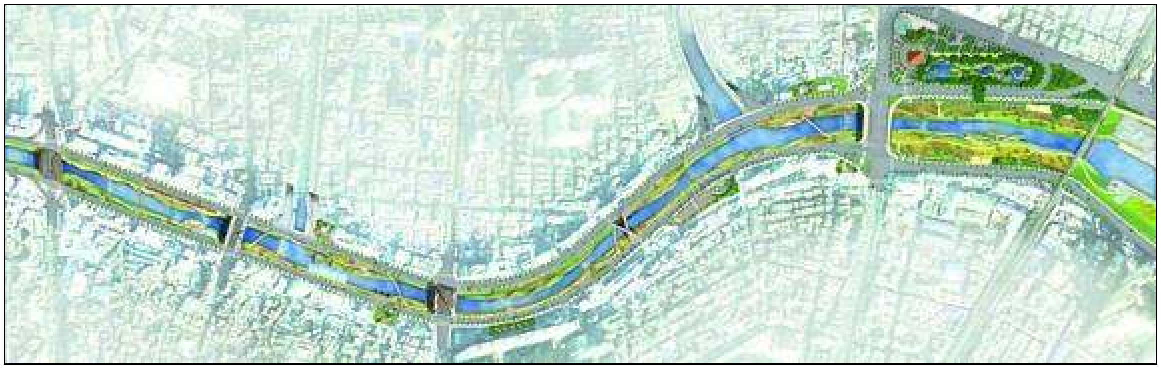
Construction



Today

After a $384 million project which removed 5 kilometers of elevated highway, today's stream is liberated. Picnickers cool their feet in its water and carp swim in its pools, up to 8 meters wide and 1 meter deep.

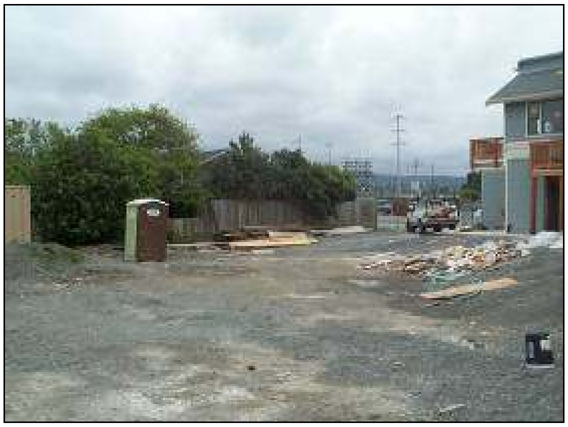
The Cheonggye Sunken Stone Garden is located at the beginning of the project corridor. Since its completion in 2005, the plaza has seen 10 million visitors.



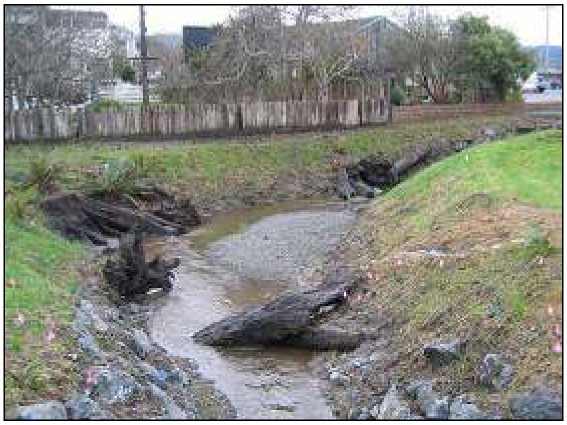
The ecosystem along the Cheonggyecheon has been enriched, the number of fish species increasing from 4 to 25, bird species, from 6 to 36 and insect species, from 15 to 192.

Jolly Giant Creek, Arcata, California

A mere 50 meters long, Jolly Creek's a miniscule public work, but as a daylighted stream on school property, students can study aquatic habitat. Total cost: $120,000.



Before

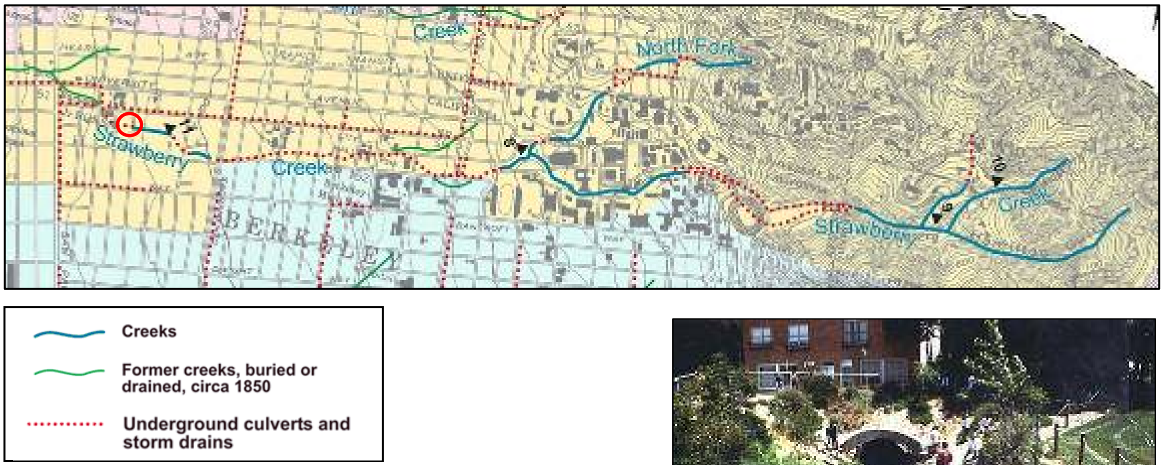


After

Strawberry Creek Park, Berkeley, California

Santa Fe Railroad abandoned its railyard in west Berkeley in 1974. Under city control, the site sat vacant for eight years until city transformed the property into a neighborhood park by daylighting 60 meter of a the creek.

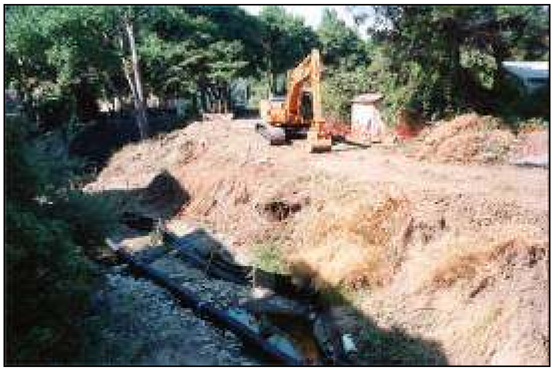
As can be seen on the map below -- the park being in the red circle -- much of greater Strawberry Creek watershed remains culverted.


Creek
North Fork
Strawberry
Creek
BERKELEY
Strawberry
Creek
Creeks
Former creeks, buried or drained, circa 1850
Underground culverts and storm drains

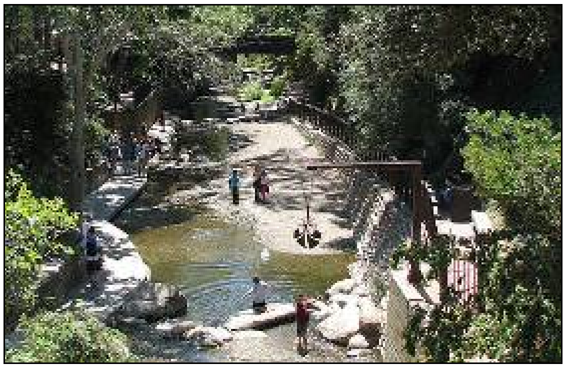
Designed for the 100-year storm event, daylighting has proven to provide storm water benefits, rather than the increased flood hazards that opponents had feared.

San Luis Obispo Creek, San Luis Obispo, California

Downtown San Luis Obispo experienced serious flooding in 1969 and 1973 when due to years of dumping, sedimentation, and neglect, San Luis Obispo Creek's 80-year old culvert could not accommodate the storm water.



Before

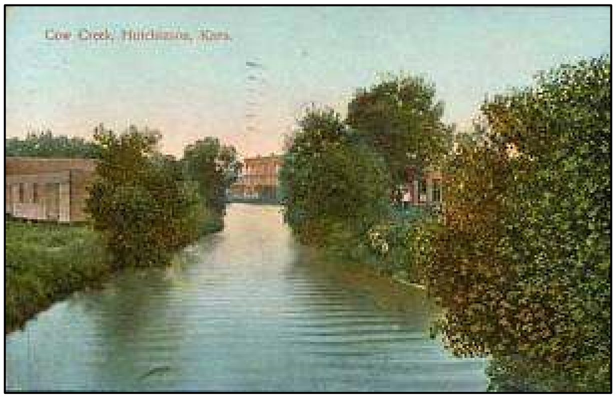


After

Daylighting included the partial closure of Monterey Street and the creation of a public garden, end result being Mission Plaza in the heart of downtown

Cow Creek, Hutchinson, Kansas

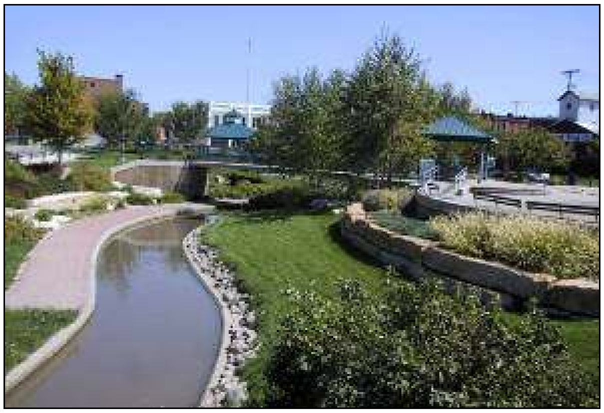
Like many growing cities, Hutchinson diverted its urban streamflow into a culvert.


Cow Creek, Hutchinson, Kans.

Cow Creek, 1920s postcard

By the early 1990s, however, Cow Creek pipes beneath the streets were deteriorating, the downtown was flooding, a major bridge needed replacing, buildings were vacant and crime was increasing.

Pre-construction



Post- construction

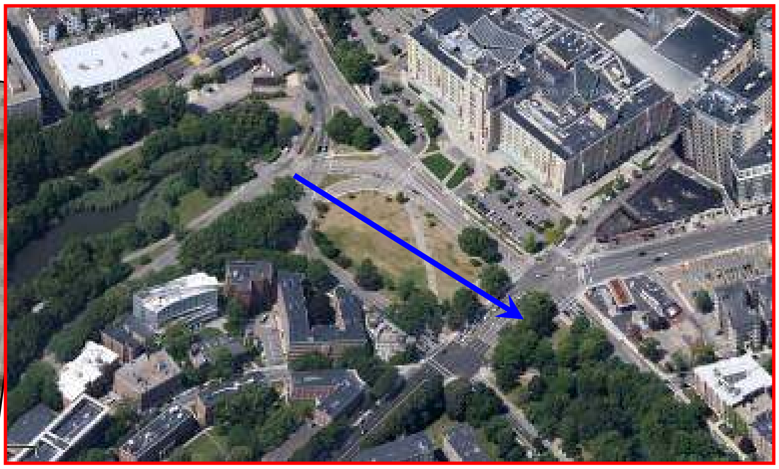
Three blocks of Avenue A were excavated to daylight 240-meters of Cow Creek. Four commercial buildings were moved. Cow Creek is now the centerpiece of a park that includes a grassy amphitheater and water-play.

Muddy River, Boston, Massachusetts

In anticipation of roadway widening, Boston's Muddy River was enclosed in the 1940s at the Fens Bridge and Brookline Avenue. The site became a Sears Roebuck parking lot in 1955, but is now just a field with sparse trees, a far cry from Frederick Olmsted's 1880 city park design.

The plan is to daylight some 200 meters as part of a $75 million project.

Olmsted's design



Once a Sears parking lot, now mostly bare ground

Arcadia Creek, Kalamazoo, Michigan

When an industrial city, Kalamazoo buried Arcadia Creek, but by the 1980s, the city center had vacant buildings, high crime and declining public use. The streets often flooded.

As part of a 13-block redevelopment plan begun in 1986, Kalamazoo daylighted 475 meters of Arcadia Creek.

The result has been spectacular. The new Arcadia Creek Amphitheater earns $12 million annually, more than paying for the park's $7.5 million price tag and its $50,000 annual maintenance. Annual property tax revenues near the opened creek have risen from $60,000 to $400,000.

Construction

Today

Arcadia Creek's name makes good on the slogan of Chapter 28, Et In Arcadia Ego.

Grand River, Jackson, Michigan

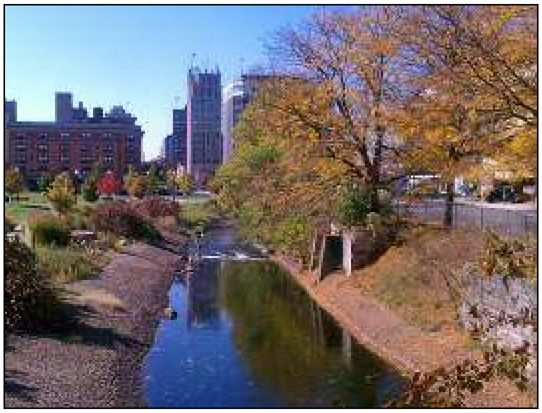
The Grand River was capped with concrete in 1937 to contain its smell and provide downtown parking.

Since 1978, six children have been trapped under the cap and drowned. The 600-meter Grand River Cap Removal project was undertaken in response to the deaths.

Grand River, Jackson, Mich.

1910 postcard

Capping

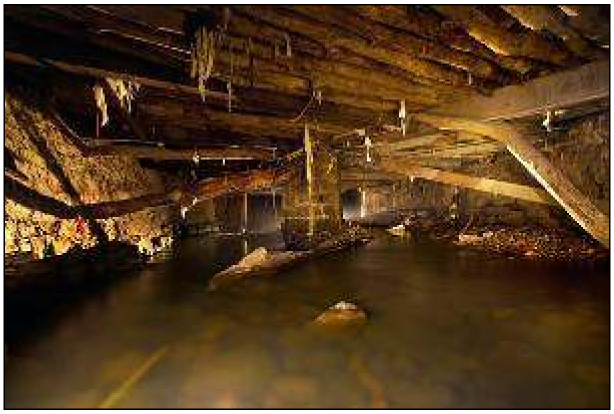


Today

Sawmill River, Yonkers, New York

Sawmill River is the longest tributary of the Hudson, 37 kilometers. A subterranean flume completed in 1922 banished 1 kilometer beneath the Yonkers city center.

Enclosing the Saw Mill River, 1917

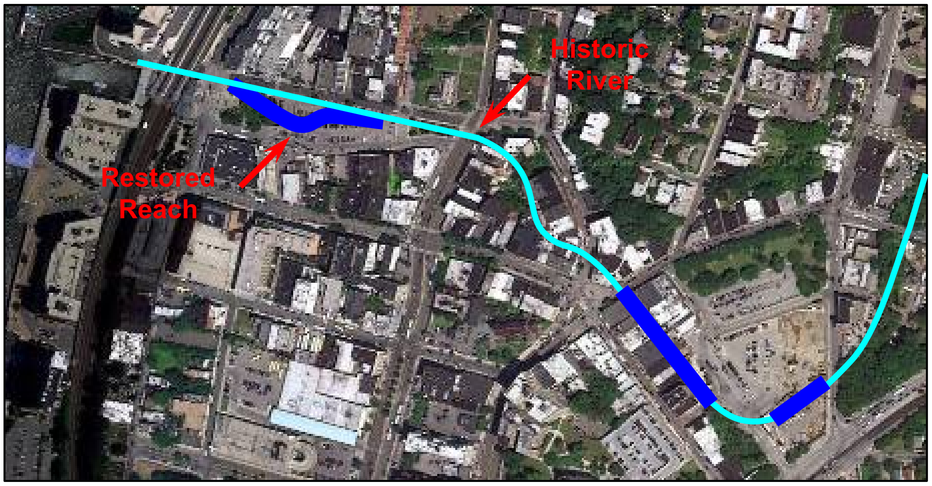


The subterranean river

A $3 billion urban core revival includes $42 million to re-expose 600 meters of the river and line it with paths and restaurants.

Another stretch will become a wetland park.

Daylighting began in 2007.



Meadow Creek, Charlottesville, Virginia

In its early years, the University of Virginia had marshes and ponds scattered throughout the campus. The largest waterbody, variously known as the "skating pond," the "ice pond," "the university pond," or, simply "the pond," was fed by Meadow Creek.

In 1864, Gen. George A. Custer's Union troops crossed "the creek at the bottom of the university pond."

David Culbreth's The University of Virginia: Memories of her Student-Life and Professors (1908) recalls the lake in 1874.

> *A number of old ladies also have participated in the sport under the escort of experienced friends -- one had the misfortune of taking the cold dip with her beaux companions, but was not intimidated, as on the morrow she again led the procession.*

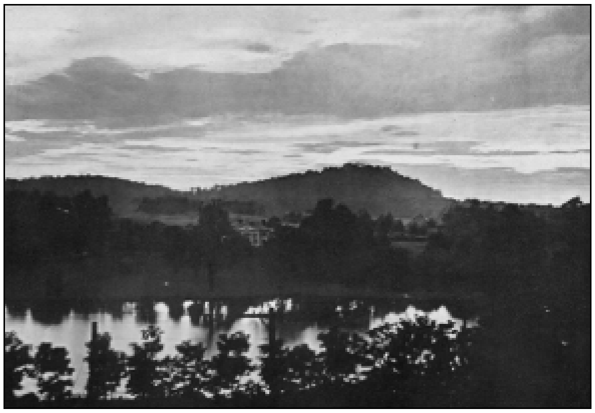
In 1922, excavation began for the university's new gymnasium. From a contemporary account in the campus paper,

> *The work now under way consists in the removal of 7,000 cubic yards of dirt for the foundation of the new building. In disposing of this, a large portion will be dumped into the lower end of the University Pond.*

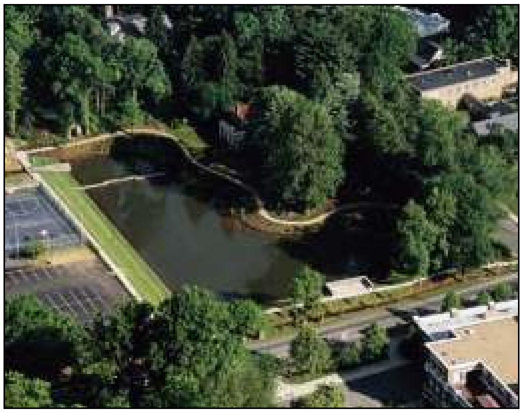
By 1940, the newspaper noticed that the shrunken pool was fouled by effluent from the gym showers and swimming pool.

> *The Reflection Pool could very easily be a spot of beauty. Now it looks much like a mud hole.*

In the summer of 1952, the paper branded the feature as a "sunken mire," and the remainder was filled to create a new parking lot and athletic field.

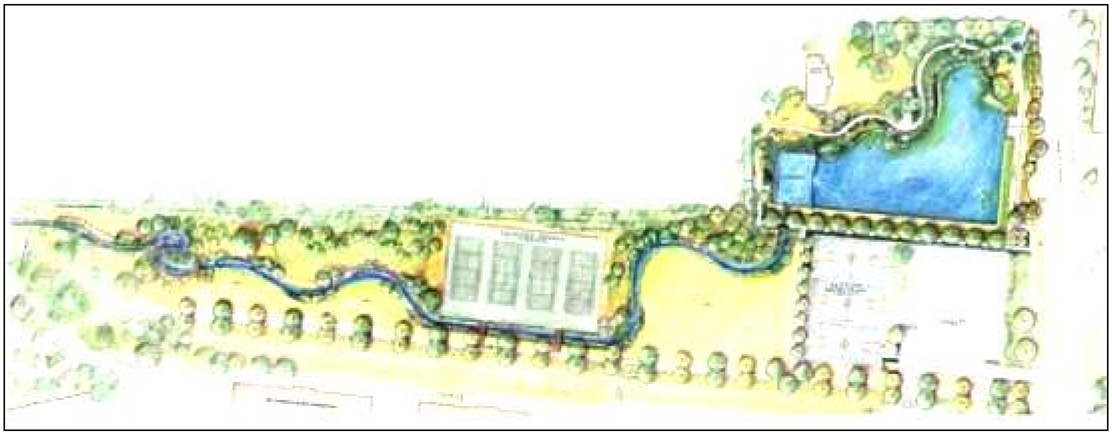


1919



Today.

Restoration of the 4.5-hectare "Dell," as it's now called, featuring an L-shaped pond and daylighting 360 meters of Meadow Creek, was competed in 2004. The basin two has straight edges to blend with the surrounding built environment.



Unlike many daylighting projects, the effort's goal was not that of ecosystem restoration, but rather that of historical reclamation.

Costs

Urban Stream Daylighting, Case Study Evaluations (2007), Virginia Water Resources Research Center, by Tracy Buchholz and Tamim Younos, provide some cost comparisons

Daylighting Cost

Length (meters)	Cost/linear meter
< 80	$220
80 - 300	$320
> 300	$2600

The values will inflate with time, of course, but the diseconomy of scale is obvious. It's cheaper to daylight 1 meter of a small project than 1 meter of a large one. The pipes are smaller, of course, but more than that, larger sewers underlay larger urban areas, and thus larger infrastructure needs to be removed.

CHAPTER 86

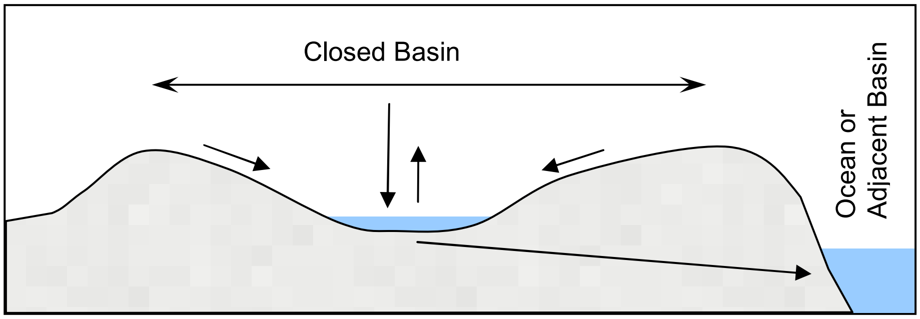
THE RIO SAN BUENAVENTURA

This chapter can be divided into two parts.

The first section of this chapter, A River Discovered and Discarded, traces the quest for a river reputed to link America's Great Basin (the closed -- or "endorheic" -- watershed encompassing most of Nevada and western Utah) to the coast of California. The quest was doomed form the start, however, as by definitional, a river can not flow out of a closed basin. Water ponded in a closed basis is a "terminal lake," of which a closed basin may have more than one. The largest terminal lake in the Great Basin is the Great Salt Lake.

The remainder of the chapters explores a possibility not considered by those who looked on the surface, the possibility that this river is subterranean. Such a river from Utah to California may seem preposterous, we admit, but we're just reporting what's been said. There is no hydrologic preclusion of subsurface water exiting a closed basin.

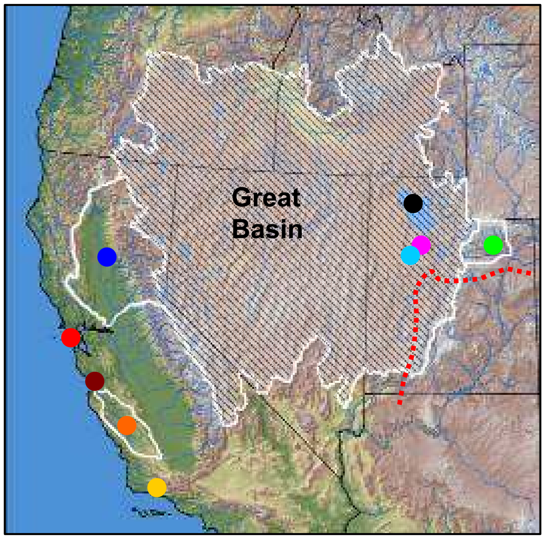
The schematic,



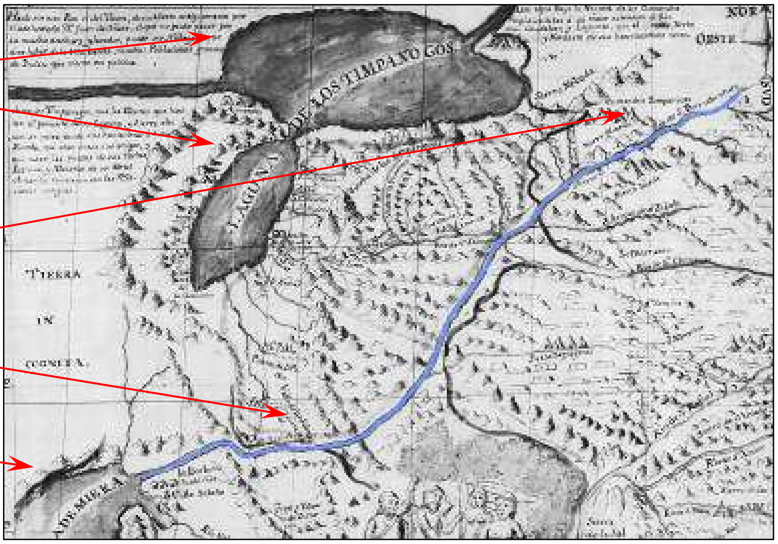
A River Discovered and Discarded

The map indicates geographic locations associated with this section.

- ● San Francisco Bay
- ● Monterey Bay
- ● San Buenaventura Mission
- ● Great Salt Lake
- ● Utah Lake
- ● Sevier Lake
- ● Green River Headwaters
- ● Salinas Watershed
- ● Sacramento Watershed
- ····· Dominguez-Escalante, 1776



Bernardo Miera y Pacheco was cartographer on the Dominguez-Escalante 1776 expedition seeking a land route from Santa Fe to Monterey.


LAGUNA DE LOS TIMPANOGOS
NORTE
OESTE
SUD
TIERRA IN COGNITA
MIERA

"Laguna De Los Timpanogos" comprises both the Great Salt Lake and Utah Lake.

The upper reach of "Rio San Buenaventura," as named by Miera, does not drain as drawn, but rather south to the Green River.

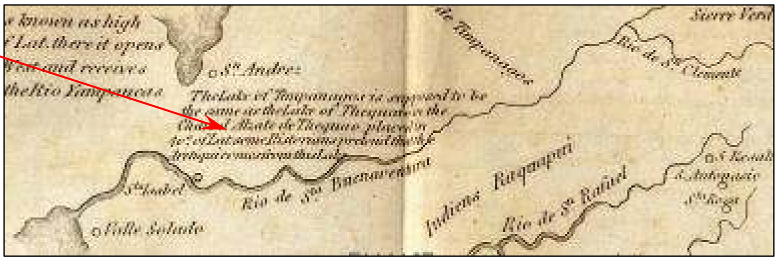
The lower reach is the Sevier River.

"Laguna de Miera" is Sevier Lake.

Bernardo Miera (1778)

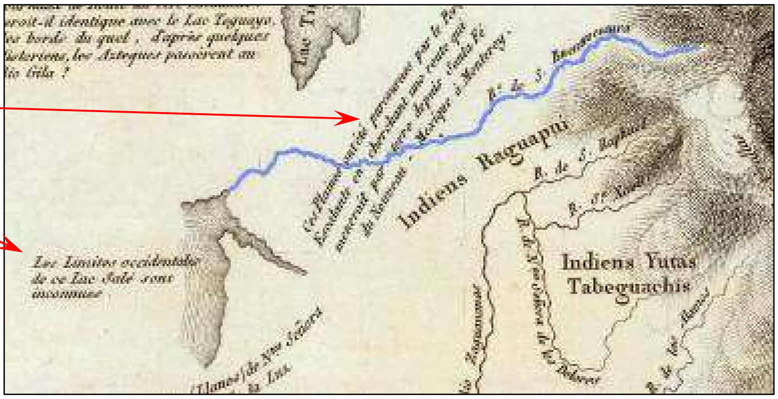
Miera believed that a broad river makes its way from the Great Salt Lake to the California coast, but as seen by the expedition route, he never ventured that far north. There is no such outlet, but if there were, it would terminate in a lower sump within the Great Basin.

Miera's speculation that the Rio San Buenaventura may also continue to the Pacific is flawed for the same reason, but we're privy to topographic surveys. At the close of the 18th century, Miera's work comprised the totality of mapping for the region and the Rio San Buenaventura was to quickly become a fixture on geographies of the new continent.


known as high
Lat. there it opens
and receives
the Rio Timpanogos
S^t. Andres
The Lake of Timpanogos is supposed to be the same as the Lake of Theguayo
Rio de S^n. Buenaventura
S^ta. Isabel
Valle Salado
Indiens Raguapui
Rio de S^n. Rafael
Rio de S^n. Clemente
Sierra Verde

Some Historians pretend that the Aretiqui comes from this Lake -- a reference to a Northwest passage to India.

Zebulon Pile (1810)

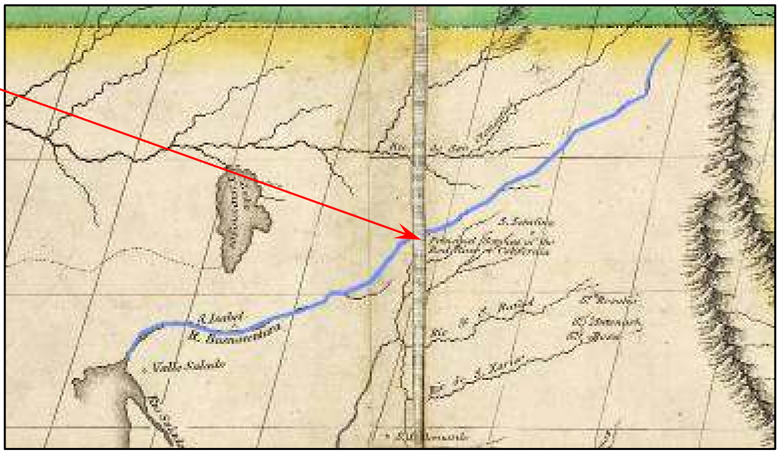

paroit-il identique avec le Lac Teguayo, sur les bords du quel, d'après quelques historiens, les Azteques passèrent au Rio Gila ?
Buenaventura
R. de S.
Indiens Raguapui
R. de S. Raphael
Indiens Yutas Tabeguachis
Les Limites occidentales de ce Lac Salé sont inconnues
Llanos de Nra Señora de la Luz

These Plains have been traversed by Father Escalante in search of a route by land from Santa Fe to Monterey.

The Western Limits of this Salt Lake are Unknown.

Alexander von Humboldt (1811)

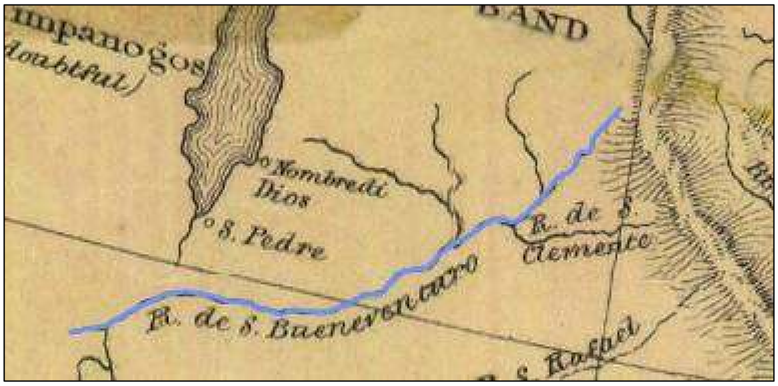
Principle sources of the Red River of California, i.e., the Colorado.


S. Isabel
R. Buenaventura
Valle Salado

J. Finlayson (1822)

Jedediah Smith crossed the Great Basin in 1827 in search of the San Buenaventura, and in the following year searched the western flank of the Sierra Nevadas, but failed to find the river.

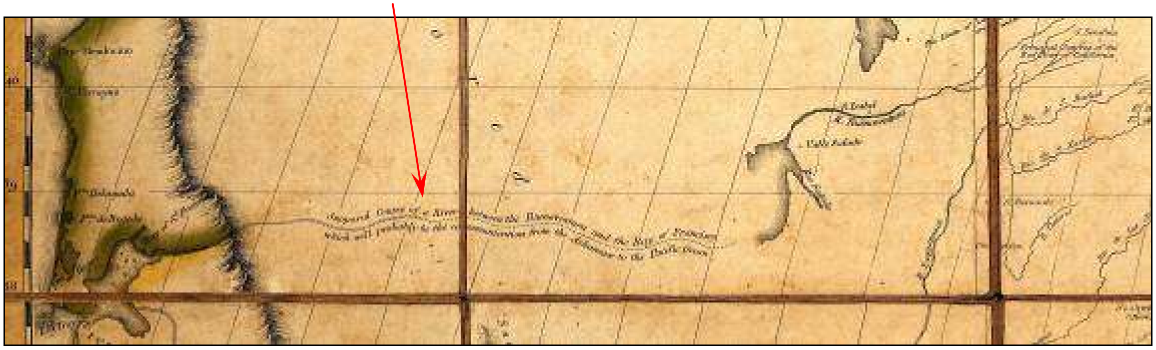
"A Map of America Denoting the Boundaries of the Yearly Meetings of Friends and the Locations of the Various Indian Tribes." Lake Timpanogos is "doubtful," but the river is not.


mpanogos
(doubtful)
AND
Nombre di Dios
S. Pedro
R. de S. Clemente
R. de S. Buenaventura
S. Rafael

James Bowden (1844)

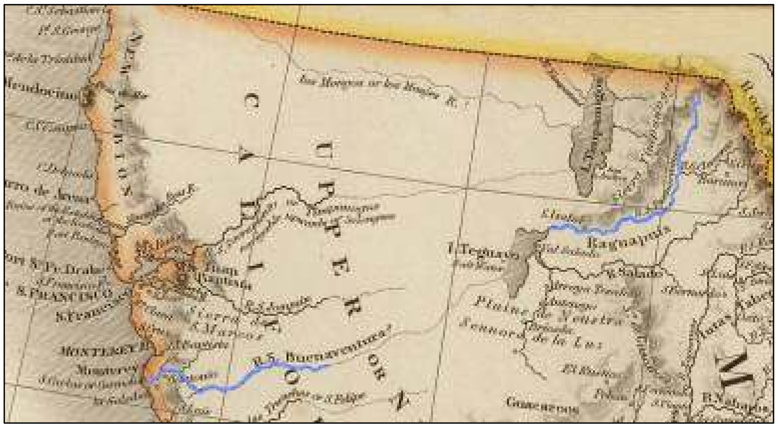
And to the west,

Supposed Course of a River between the Buenaventura and the bay of Francisco which will probably be the communication from the Arkansas to the Pacific Ocean



John Melish (1818)

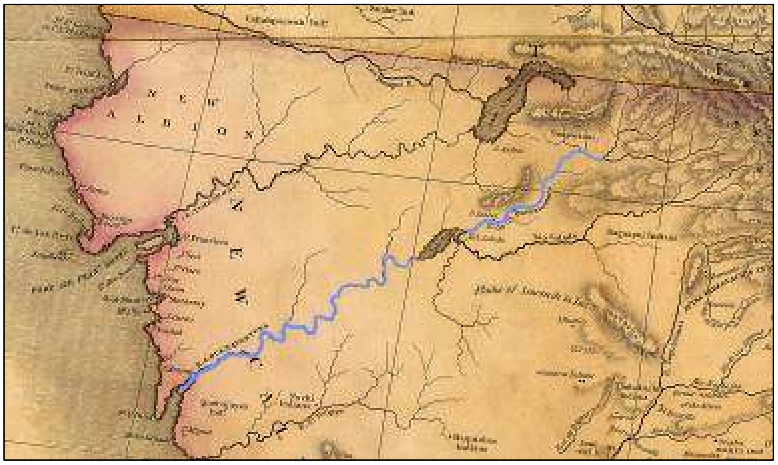
Connecting Morse's waterways, if only by a dotted line, belies the confidence of a nation's Manifest Destiny.


UPPER
CALIFORNIA
NEW ALBION
S. Francisco
Monterey
R.S. Buenaventura?
Raguapuis
Plains de Neustra Sennora de la Luz
R. Salado

Sidney Hall (1828)

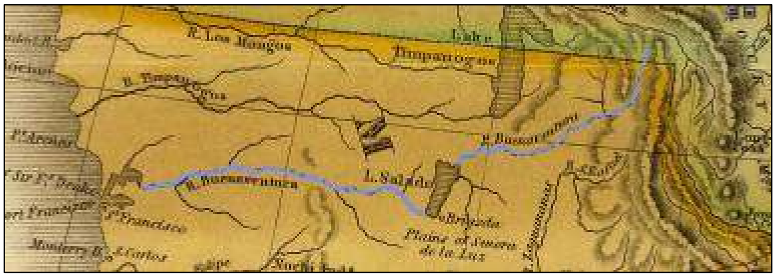
Shown north of the San Buenaventura are two rivers from the Great Salt Lake: the Sacramento to San Francisco Bay ("navigable upwards of 50 Leagues") and the Mongos to the Rogue River in Oregon. The mouth of the San Buenaventura itself has dropped below Monterey.

The same rivers, but not with the uncertainty of dotted lines.



Henry Tanner (1822)

Disagreement persisted concerning where the San Buenaventura enters the sea, but all agreed that the river arrives.


R. Los Mongos
Lake Timpanogos
R. Timpanogos
M
R. Buenaventura
L. Salado
Plains of Senora de la Luz
S. Francisco
Monterey B.

Albert Finley (1826)

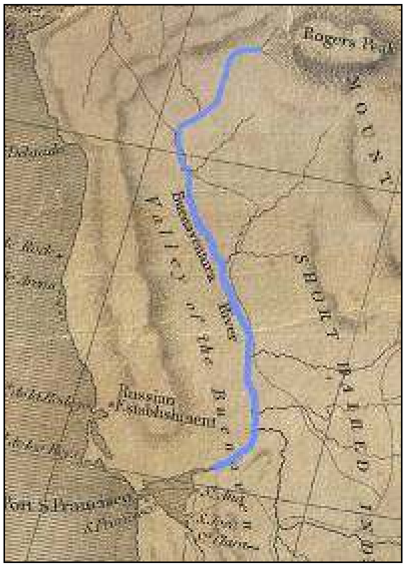
John Bidwell, guide the first wagons across Utah in 1841, noted that maps claimed the Great Salt Lake to have two outlets, each larger than the Mississippi, running into the Pacific

> *An intelligent man with whom I boarded had a map which showed these rivers (one was the Buenaventura) to be large, and he advised me to take tools along to make canoes, so that... we could descend one of these rivers to the Pacific.*

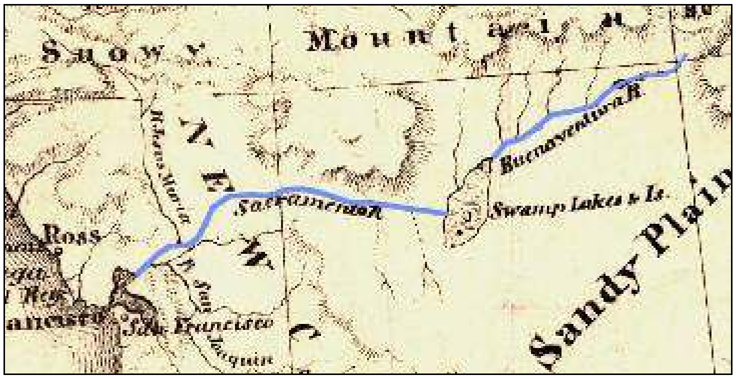
Unfortunately for Bidwell's party, canoeing didn't prove to be an option.

There were, of course suspicions that the river might be less than advertised

David Burr wavered between the San Buenaventura as but the Sacramento familiar to residents of San Francisco, and a Sacramento completing the legendary San Buenaventura.



David Burr (1839)



David Burr (1840)

The mapmakers were unanimous in endorsing a San Buenaventura, but couldn't agree on its location. We've seen a similar quandary earlier in our study. Until the Scientific Revolution, authorities were clear regarding the direction of subterranean channels. Natural philosophy was an exercise in thought, not physical examination, and it was Biblical truth that water ran from the sea to the mountaintops. The vexing aspect was that of physical confirmation.

In similar manner, there had to be a Great River of the American West because for so long, such a river was said to exist. That is until someone with sufficient authority actually looked.

The June 1833 notes of Zenas Leonard, Bonneville-Walker Expedition, are clear on the matter.

> *There is a large number of water courses descending from this mountain on either side -- those on the east stretching out into the plain, and those on the west flow generally in a straight course until they empty into the Pacific; but in no place is there a river course through the mountain.*

Why, we may ask, wasn't the San Buenaventura's nonexistence promptly made known to the mapmakers? As we'll see with the next explorer, refutation of the San Buenaventura perhaps wasn't what Washington cared to hear.

Rio San Buenaventura remained a river of uncertainty until 1843, when Lt. John Fremont, with Kit Carson scouting, led an expedition from the Columbia River to Sacramento via the Sierra Nevadas. Fremont planned to reach the river to refuge from the worst of winter.

COL. FREMONT

From Fremont's journal,

November 18, 1843; The Dalles.

> *From this lake* [the modern Klamath] *our course was intended to be about southeast, to a reported lake called Mary's, at some days journey into the Great Basin; and thence, still on southeast, to the reputed Buenaventura River, which has had a place in so many maps, and*

> *countenanced the belief of the existence of a great river from the Rocky Mountains to the bay of San Francisco.*

January 3, 1844; Mud Lake.

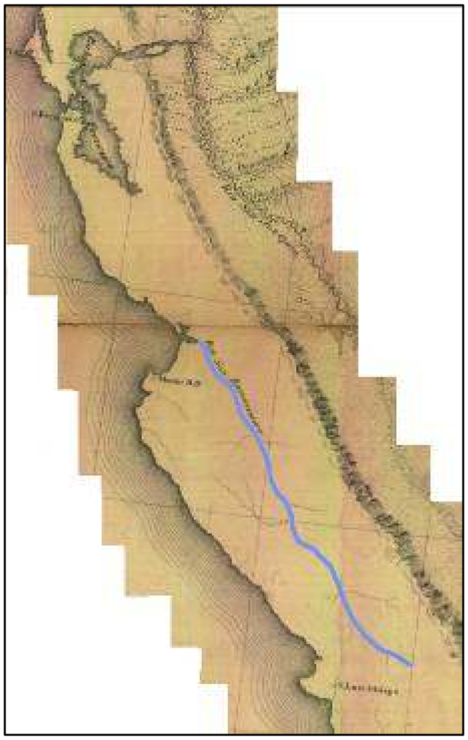
> *We were evidently on the verge of the desert which had been reported to us; and the appearance of the country was so forbidding, that I was afraid to enter it, and determined to bear away to the southward, keeping close along the mountains, in the full expectation of reaching the Buenaventura River.*

January 17, 1844; Pyramid Lake/Truckee River.

> *With every stream I now expected to see the great Buenaventura; and Carson hurried eagerly to search, on every one we reached, for beaver cuttings, which he always maintained we should find only on waters that ran to the Pacific; and the absence of such signs was to him a sure indication that the water had no outlet from the great basin.*

January 29, 1844; Antelope Valley, West Fork of Walker River.

> *Walker subsequently informed me that, like myself, descending to the sourthward on a more eastern line, day after day he was searching for the Buenaventura, thinking that he had found it with every new stream, until, like me, he abandoned all idea of its existence, and, turning abruptly to the right, crossed the great chain.*

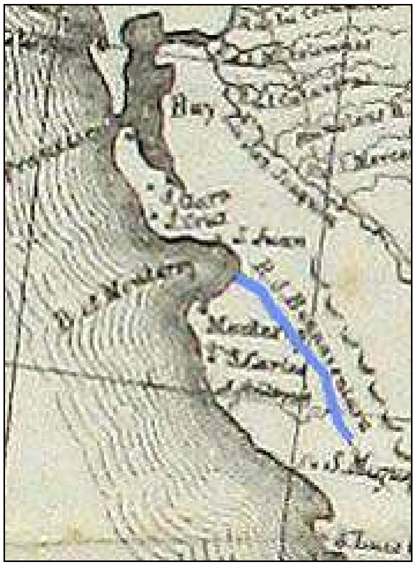


Fremont was not quick to entirely dismiss the waterway, however, and found a satisfactory solution by deeming the river running to Monterey Bay from near the San Buenaventura Mission in Southern California to be the Rio San Buenaventura. Today, it's the Salinas. A portion of Fremont's map is to the right.

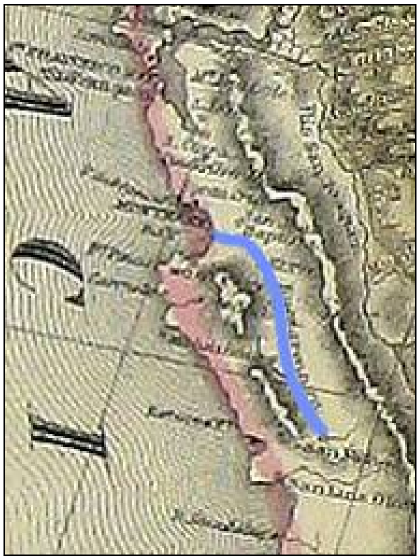
April 14, 1844; Leaving the southern end of the San Joaquin Valley.

> *It had been constantly represented, as I have already stated, that the bay of San Francisco opened far into the interior, by some river coming down from the base of the Rocky Mountains, and upon which supposed stream the name of Rio Buenaventura had been bestowed.. No river from the interior does, or can, cross the Sierra Nevada -- itself more lofty than the Rocky Mountains; and as to the Buenaventura, the mouth of which seen on the coast gave the idea and the name of the reputed river, it is in fact a small stream* [Salinas River] *of no consequence... There is no opening from the bay of San Francisco into the interior of the continent.*

Fremont's ended hope for a trans-Rocky waterway and for a time the name "Buenaventura" was applied to the Salinas River.

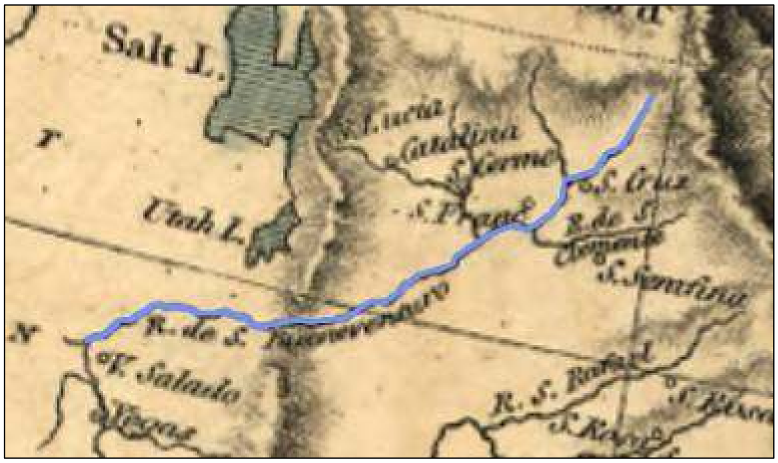


Julius Hutawa (1848-1849)



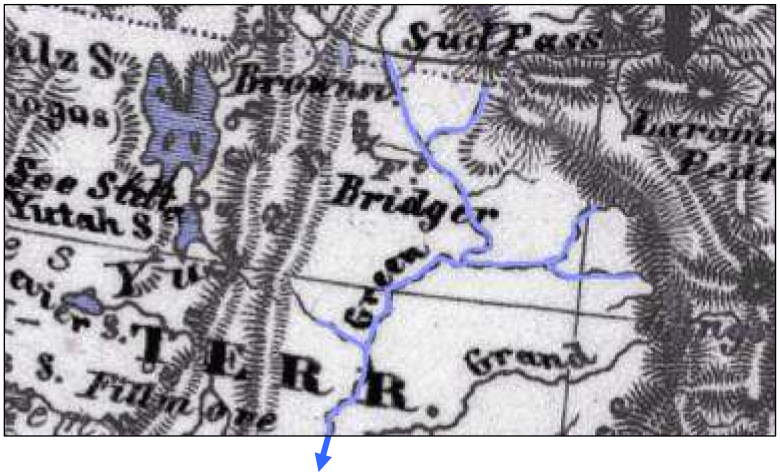
J.H. Colton (1849)

Although Miera's Rio San Buenaventura was now known not to reach California, his river remained on many maps until the 1850s.



John Smith (1849)

The higher reaches traversed by Miera drain southward to the Green River, not westward through a mountain pass. Sevier River is correctly shown as a short tributary to the lake.



Adolph Stieler (1856)

Fremont's diary from when he was in Washington in early 1845 suggests that the challenge of refuting the legendary river was more than cartographic.

> *The president* [Polk] *seemed for the moment skeptical... Like the Secretary* [of the Navy] *he found me "young," and said something of the "impulsiveness of young men," and was not at all satisfied in his own mind that those three rivers* [including the San Buenaventura] *were not running there as laid down* [on previous maps.]

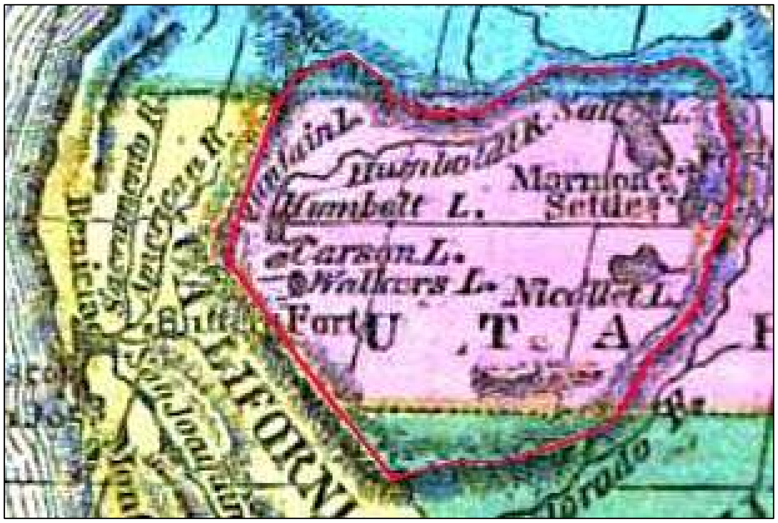
No American President, of course, wants to lose his or her allotment of national destiny.

Fremont's final thoughts on the matter, from the April 1891 Century Magazine,

> *A river, the "Buenaventura," indicated upon a map furnished me by the Hudson's Bay Company as breaking through the mountains, was found not to exist.*

The Great Salt Lake was not fully circumnavigated until 1849 by Howard Stansbury who declared that no river flowed outwards and the hydrologic containment of the Great Basin was at last recognized.

We've highlighted the conceived boundaries in red, reasonably close to the mapping of today.



Marcius Willson (1854)

To this point we've been discussing a Rio San Buenaventura said to flow out of a closed basin. Not knowing that the Great Basin is a closed watershed, however, the river was discarded by mapmakers of 19th century simply because nobody could actually verify its existence.

There's much more that can be pieced together about a Rio San Buenaventura that flows to the sea underground.

The Great Salt Lake

In Chapter 35, Underground Rivers in the Fine Arts, we noted the thesis of painter George Catlin that a Mississippi-scale underground river drains Utah's Great Salt Lake to the Gulf of Mexico. Let us now consider an outlet in a westward direction.

A lake surface seeks the elevation at which the lake's losses equal its gains. When inflow increases, the water level rises, providing increased head pushing discharge through the lake's outlet, increased pressure-driven infiltration into the lake bed, and increased water surface area, thus greater evaporation. When inflow decreases, the lake surface falls for like reason.

Thus observing a lake over a number of years, we can algebraically compute unknown components.

Direct Precipitation + Stream Inflow + Groundwater Inflow = Evaporation + Stream Outflow + Groundwater Outflow

Rearranging,

Direct Precipitation + Stream Inflow - Stream Outflow - Evaporation = Groundwater Outflow - Groundwater Inflow

Substituting known values in millions of cubic meters/year,

$$\boxed{1{,}109} + \boxed{2{,}361} - \boxed{0} - \boxed{3{,}577} = \boxed{\begin{matrix}\text{Groundwater}\\ \text{Outflow}\end{matrix}} - \boxed{\begin{matrix}\text{Groundwater}\\ \text{Inflow}\end{matrix}}$$

The zero identifies the waterbody as a terminal lake.

Again rearranging,

$$\boxed{\begin{matrix}\text{Groundwater}\\ \text{Outflow}\end{matrix}} \quad \boxed{\begin{matrix}\text{Groundwater}\\ \text{Inflow}\end{matrix}} = \boxed{-107}$$

Seepage into the Great Salt Lake from the mountains above it exceeds whatever seeps out of the lake by 107,000,000 cubic meters/year. This is not to say that nothing exits through the bed, but rather to indicate that at best, the magnitude is comparatively small.

But as we are by now well aware, science has played a role in such discussion in only recent history. The Great Salt Lake, according to Native American legend, was once connected to the Pacific by a subterranean river which caused treacherous whirlpools in the lake's center.

And as we are also aware, lore can build upon lore.

The River Sidon, the only river mentioned by name in the Book of Mormon (Alma 22:27-34) in some aspects resembles the Rio San Ignacio of Baja California. The Lamanite and Nephite armies were said to have crossed the Sidon multiple times with seemingly ease. The modern San Ignacio can be waded with little effort, as much of its headwater seeps into the alluvium and reaches the sea underground. Brigham Young would have thus have been attuned to the subterrain when in 1847 he declared, "This is the place."

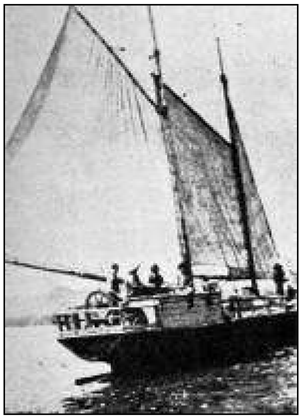
From The City of the Saints, and Across the Rocky Mountains to California (1862) by Richard F. Burton,

> *The watershed of the Basin is toward the north, south, east, and west; the affluents of the Columbia and the Colorado Rivers carry off the greatest amount of drainage. One of the geographical peculiarities of the Territory is the "sinking," as it is technically called, of the rivers. The phenomenon is occasioned by the porous nature of the soil. The larger streams, like the Humboldt and the Carson Rivers, form terminating lakes. The smaller are either absorbed by sand, or sink, like the South African fountains, in ponds and puddles of black mire, beneath which is peaty earth that burns as if by spontaneous combustion, and smolders for a long time in dry weather; the waters either reappear, or, escaping under the surface -- a notable instance of the "subterranean river" -- feed the greater drains and the lakes. The potamology is more curious than useful; the streams, being unnavigable, play no important part in the scheme of economy.*

"Potamology," is the scientific study of rivers, not the family doctrine peculiar to the settlement through which Burton had recently passed. The concluding sentence would prove to be one of the greater misstatements of American exploration.

The drama of the hydrology was to grow, soon to include whirlpools.

> *Reported Discovery of a Subterranean Outlet -- Force of the Whirlpool. A subterranean outlet to the Great Salt Lake has been found opposite Corinne, and between Fremont and Kimball Islands. The schooner Pioneer, Capt. Hannah, while sailing in that vicinity last Sunday, was drawn into an opening, which is an immense maelstrom, or stupendous whirlpool, and the descent and circular motion of the water were so rapid and violent that the vessel was made to spin around in it with frightful velocity, and it was only by a high wind prevailing at the time that she was enables to sail beyond the influence of the awful chasm. Capt. Hannah reports that he has no doubt whatever that this opening (never before discovered) is the grand outlet of the lake.* -- New York Times; June 10, 1870



Great Salt Lake schooner

And soon would follow, in the spirit of the Great Kircher (Chapter 8) the inevitable supposition of a subterranean river.

The British publication Anglo American Times, July 9, 1870, provides the lucid details.

> *In a former number we alluded to the underground outlet supposed to have been discovered for the surplus waters of the Great Salt Lake. The subject is of much geographical interest, for the wide basins of the country between the Rocky Mountains and the Sierra Nevada without an outlet for the waters pouring down the vast mountains support the supposition that a great subterranean river flows thence to the sea, as a distinguished geographer alleges. The following details are taken from a paper of Corinne, Utah:*
>
> *One night last week the schooner Pioneer, Capt. Hannah, on our voyage from Corinne to Stockton, when at a point in the lake between Freemont and Kimball Islands, nearly opposite this city, came suddenly in contact with something which the captain thought more solid than water, believing his vessel to have stranded upon rocks. Instead of this, however, the men on the Pioneer discovered that she was in the whirl of a maelstrom, for the vessel immediately revolved as if in a circular current; and the motion was so rapid in the revolutions made that the men could scarce stand to their duties. Capt. Hannah being an old sailor, and understanding the danger he was in, at once added sail, and, a brisk wind blowing at the time, the craft was, after about half-an-hour's detention, borne beyond the vortex of the eddy. He informs Gen. Connor, the owner of the schooner, and from whom we get these interesting facts, that while in the trough of the ugly hole the deck was far lower than the water outside the whirlpool, and that he owes the safety of vessel and men to the stiff breeze which fortunately sprung up at the time. The noise of the waters as they descended denoted that some mighty airless cavity below gave strength to the suction, and the surging, frothy foam above was like the boiling of a mammoth cauldron. That this is the safety valve of Great Salt Lake there seems to be no doubt, and we can reasonably assume that similar openings are numerous on the bottom.*

"Utah Notables, Captain John Hannan," Salt Lake Daily Tribune, April 5, 1873, provides a bit of followup.

> *On one of his succeeding voyages upon this stormy sea* [the Great Salt Lake]*, he discovered what will ever embalm his name in the living luster of fame, to-wit, the great whirlpool or maelstrom of Utah, the outlet and subterranean passage of the water from Salt Lake. The long sought-for explanation of what became of the water that forever flows into the lake was finally given by Capt. Jack by his discovery of the whirlpool, through which said waters were wont to leak out at the bottom*
>
> *This discovery was made just at the vesper hour, as the sun was going to set. The sloop Polly Ann was being imperceptibly drawn into the abyss. Captain Jack and Jim McGosling had been "laying toward leeward" of a keg of Canadian whiskey, supplied them by General Conner, and hence did not watch closely for calamities. Hearing a roaring noise like holding a conch shell to*

> *one's ear, Cap looked over the gunwale and saw a fearful maelstrom. He got sober quicker than he could say "Jester Clinton," and so did Jim. Cap's experienced eye took in the situation in an instant. The sun was just sinking out of sight, and he felt as did Byron Manfred on his last day, just as the glorious orb was oozing away. Just then Cap saw a rippling of the smooth surface of the sea and he knew that a gust of wind was passing over the whirl of the maelstrom towards his craft. "Let loose the jib-boom and spread the main sail," shouted Capt. Jack in a voice so familiar to all frequenters of Main Street. "Hoist the top gallant -- unreel the halyards -- cut loose the caboose and hold taut the capstan," again shouted our hero, in that melodious strain so much resembling the song of the animal upon whose back our Savior received his first lesson in equestrianship.*
>
> *His orders were obeyed -- the "gust" aforesaid caught the sails and carried the Polly Anne safely out of the whirl is had been revolving in, into the smooth open sea, from where he soon after sailed up Barr Creek to Careen and gave the intelligence of his astounding discovery for Dr. Cass and Judge Toohy, who sent it widely over the wires to the utmost ends of the earth, to enlighten and make happy the scientists of every clime and country. This truthful history of the discovery of the outlet of the waters of Salt Lake proves it to be a more reliable institution than the great serpent that Bishop Johnson discovered in Utah Lake a year earlier, both of which were discovered through agency of spiritual manifestations, and a queer kind of planchette called a jug.*

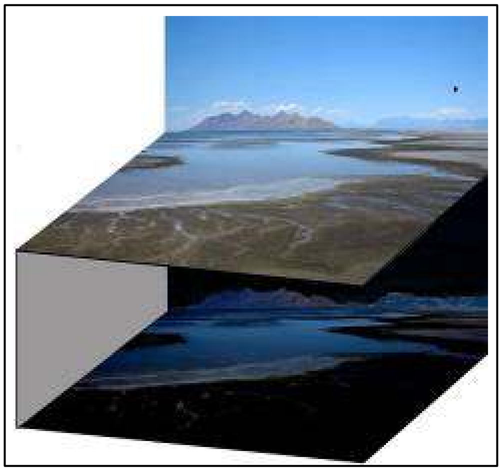
Not unlike the controversy regarding the direction of the hydrologic cycle (Chapter 7) the Salt Lake Herald of June 25, 1903, speculated the opposite, that the lake was fed by subterranean springs from a another underground river.

> *According to the theory, there are places in the bottom where holes may be found that are from six to ten feet wide. These, it is claimed, form the mouths of springs that emit volumes of fresh water into the lake the year around... Adherents to this theory claim that in seasons of heavy precipitation the earth swallows up quantities of water that percolates through the spongy soil to subterranean rivers and then finds its way into the lake through these springs.*

Absent the allusion to the underground river, this isn't far from the truth, as indeed the Great Salt Lake receives inflow from numerous seeps.

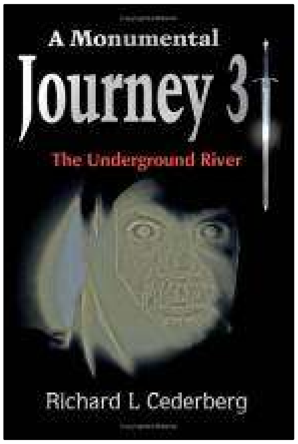
After a quantitatively-amiss case that lake evaporation is less than tributary inflow, the July 18, 1904, Pittsburgh Press revived the underground-outlet hypothesis.

> *The curious nature of the bottom is indicated by the attempt to build a railroad across the lake... In places near the center the engineers have discovered what appear to be enormous beds of quicksand... There are some spots in these portions where material has been thrown almost daily of over a year without thus far finding bottom. Several of the railroad engineers have a theory that the depressions which it seems impossible to fill are the entrance to an underground river so that as fast as the rock is thrown in, the current of the river carries it away.*
>
> *Near what is called Antelope Island is another indication that a subterranean opening exists. Frequently the waters near the island are so violently disturbed that people in the vicinity call this place the "maelstrom."'*



Bringing us up to date -- perhaps proving that human intelligence doesn't improve with successive generations -- Branton (1995) notes,

> *Certain geologists state that the Great Salt Lake has an underground counterpart deep below it, and that a certain type of earthquake could "conceivably" empty the entire contents of the lake into its subterranean counterpart. There are vague rumors of underground streams or rivers which allegedly flow from HUGE caverns in the heart of the Wasatch Mts./Western Rockies (caverns which can supposedly be entered by following the right path through the underground maze), and westward below the valley floor, possibly to the underground "counterpart" of the Great Salt Lake.*



And consider The Underground River (2006) by Richard L. Cederberg. The situation in a nutshell: Forced to put their schooner into dry-dock for repairs, the crew of the Heimdall chooses to holiday in southern Utah so they can rendezvous with the Professor, a brilliant confidant from Rabat. What he shares stuns the crew and changes their plans. Now, instead of sailing north to Montague Island, four of them will travel to a hidden base in Taroudant Morocco for secret training on state-of-the-art vessels. The others will climb Ghost Mountain to verify a recently-discovered entrance into a vast underground river system. Tearfully, both groups part company to prepare for the greatest challenge of their collective lives, an extraordinary mission into a numinous subterranean realm in search of century's old Viking civilizations.

And a bit later in the adventure,

> *"Testing, testing, can everybody hear me? Alrighty then, it's me, the big mouth comin' at ya' from downtown Oski, the mineral capital of the bloody universe on the beautiful Underground River. The stone city is about two and a half miles to the south-east of a big island in the middle of Lake Powell at about twenty- three hundred feet."*
>
> *"An island?" The Captains forehead tightened as he glanced over at Jonah, "We're under Utah then!"*

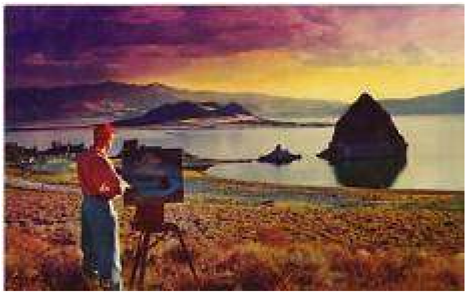
Lake Tahoe

As the underground route might pass near Lake Tahoe, we can consult "Mysteries of the Deep at Lake Tahoe," July 25, 2004, by Tom Stienstra of SFGate.com.

> *Legend is that there is a hole somewhere on the bottom of the lake that is linked to an underground river system that feeds into Pyramid Lake north of Reno. This would explain how drowning victims at Tahoe have floated up at Pyramid. Or would it? Others say it just means that bodies floated over the spillway at north Tahoe could be carried via the Truckee River to Nevada and Pyramid Lake.*

The pioneers couldn't locate the channel, of course, but that's exactly what would be expected if the San Buenaventura were underground.

Unlike Lake Tahoe which feeds it, Pyramid Lake is terminal. It rarely hurts a tale to tie it to something that appears mysterious.

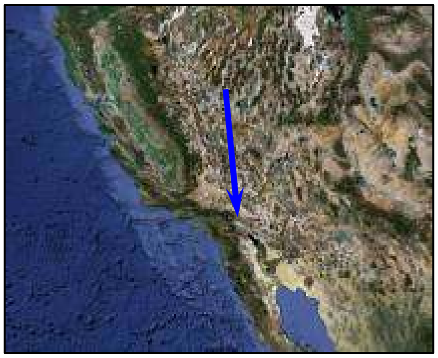


A Southern Branch?

We should, of course, allow that some hydrographic details remain unresolved. Perhaps, for example, a southward branch of the San Buenaventura.

"Government Scientists Find Trace of Underground River," Los Angeles Herald, February 20, 1909, suggests such an underground river.

> *Government experts have made a discovery which leads them to believe that there is an underground river which passes through a valley in the vicinity of Goldfield, Nevada, down through the desert country and passes near Banning, in this state. How much beyond Goldfield is may extend is a mystery on which they are now working.*
>
> *The first discovery of the existence of this great subterranean stream was an analysis of water taken from both places which were exactly similar. This was followed up with other investigations that are not yet complete, but which have progressed far enough to convince the experts that the stream exists unbroken through all those hundreds of miles.*



The map indicates the Goldfield-to-Banning flow route. The Herald continues,

> *The first discovery of the existence of this great subterranean stream was an analysis of water taken from both places which were exactly similar. This was followed up with other investigations that are not yet complete, but which have progressed far enough to convince the experts that the stream exists unbroken through all those hundreds of miles.*

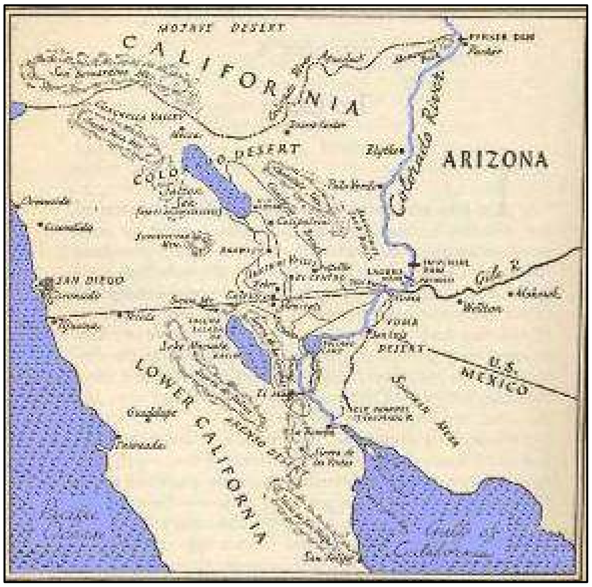
The southern route, in fact, may explain the case of the purloined Colorado River

From the September 6, 1911, edition of the Urbana Daily Courier,

> *. That the Colorado River has buried itself in an underground channel, two miles south of Yuma, was the statement of William Cranston, a mining man, who arrived here from that point. Cranston said that the mouth of the channel had not been discovered, and it was feared by the residents of that section that the river was finding its way to the Salton Sea.*

The September 5, 1911, San Francisco Call added the following,

> *An engineer of a gasoline launch on the river plying south of Yuma is authority for the statement. The immense lake at Volcano made by the river is practically dry and thousands of dead fish are stranded there, filling the air with stench. It is believed the water is flowing through an underground passage either into the Gulf of California or into Sultan Sea. In the latter event much agricultural la d in the Imperial Valley will be menaced.*



The reports may relate to the 1852 Volcano Lake earthquake which formed cracks in the clay desert near the Colorado River and caused mud volcanoes and geysers to become active southwest of Fort Yuma, where the epicenter presumably was located. Volcano Lake is the central waterbody in the map to the right.

While by all accounts the event disrupted the flow of the Colorado, there is scant geological evidence for an "immense lake" before the quake.

As we're reminded by conspiritists, however, the government doesn't want us aware of such things. Thus we must abandon our underground river somewhere under the desert.

A Northern Tributary?

In his harbinger of American expansionism, Report of the Exploring Expedition to the Rocky Mountains in the Year 1842 (1845), the same John Fremont whose report brought end to the pseudo-historic Rio San Buenaventura observed a very-real "subterranean river" exiting the bluffs above Idaho's Snake River.

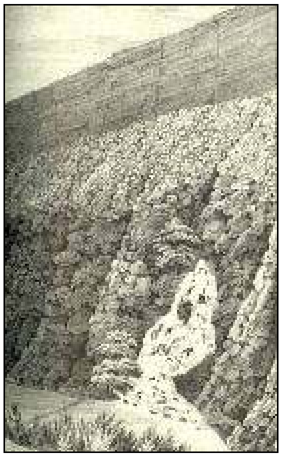
> *September 30. Immediately opposite to us, a subterranean river bursts out directly from the face of the escarpment, and falls in white foam to the river below. In the views annexed, you will find, with a sketch of this remarkable fall, a representation of the mural precipices which enclose the main river, and which form its characteristic feature along a great portion of its course. A melancholy and strange looking country -- one of fracture, and violence, and fire.*

No less an authority than John Muir left us his observation Steep Trails (1918), a reflection on the western states.

> *The Lewis, or Snake, River is nearly a thousand miles long and drains nearly the whole of Idaho, a territory rich in scenery, gold mines, flowery, grassy valleys, and deserts, while some of the highest tributaries reach into Wyoming, Utah, and Nevada. Throughout a great part of its course it is countersunk in a black lava plain and shut in by mural precipices a thousand feet high, gloomy, forbidding, and unapproachable, although the gloominess of its canyon is relieved in some manner by its many falls and springs, some of the springs being large enough to appear as the outlets of subterranean rivers. They gush out from the faces of the sheer black walls and descend foaming with brave roar and beauty to swell the flood below.*

We tipped our hat to lava tubes in Chapter 41, but nearly all subsequent examples have been those of karst hydrology. This case, however, is indeed one of lava tubes. As the Snake crosses the southern boundary of the lava plain, no tributaries enter from the north, for this is a region of streams simply disappearing into the porous volcanic rock. Idaho's appropriately-named Big Lost River seeps through the basalt, mingling with other waters for more than 150 kilometers before reemerging at Thousand Springs.

The lithograph and modern photo below illustrate the busting-out.



Outlet of Subterranean River, Fremont (1845),

Modern Riverside, Thousand Springs Reach,

Snake River

Pioneers on the Oregon Trail thus had a published picture of the wonders before them, a landscape with rivers underground!

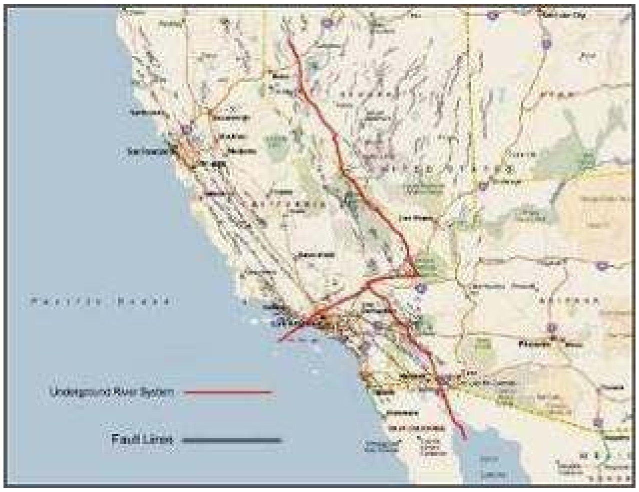
Thousand Springs was likewise wondrous to the Federal Writers' Project. From Oregon Trail: The Missouri River to the Pacific Ocean (1939),

> *The whole of central Idaho seems to be an area of subterranean rivers and possibly cavernous lake beds; at various points in this valley a person can put his ear to the ground and hear deep and troubled rumblings as of a mighty ocean rolling far beneath the surface of the earth.*

The July 1951, Popular Mechanics had the attention-drawing headline "Lost Rivers Return." The notable aspect of the article isn't about Idaho, however, it's the racism.

> *The red men referred to four major streams that tumble out of Idaho's mountains with much promise, then gradually vanish among the sands. But disappearing Big Lost River, Little Lost River, Beaver Creek and Birch Creek -- collectively known as the Lost Rivers -- are now being released from their underground prisons through the ingenuity of the white man.*

In-the-Desert.com suggests a subterranean layout based on fault lines that catches both the North and the South underground tributaries.



Nye County, Nevada

"Underground River, Where Nevada's Sunken Streams Empty Their Waters," Los Angeles Times, September 3, 1893, reports the personal reconnoitering of John L. Obendorff, "a prospector and miner well known in that State."

> *While working in the bottom of a shaft of the Monarch mine I put in a shot, and descending to see what execution had been done. I found I had broken through into what looked like a cave, with a strong current of air coming up from it. On investigation I found that the opening continued down on an incline. Determined to see what there was below, I put in a cross timber and attached a rope to it. I went down a considerable distance. In some places the opening was very narrow, and in other places four feet wide. In some places it was nearly perpendicular, but it was generally about half pitch. I proceeded down to the end of my rope, put in another cross timber and so I continued.*
>
> *When I got to the bottom I saw a wonderful thing -- a large cavern and a river flowing through it. At first I thought it was a lake, but on reaching the edge of the water I found that it was a flowing stream, and by throwing a piece of lighted paper I found that it had a current of about three miles an hour.*
>
> *I was on the southeast shore, and the bank sloped down to the water's edge gradually, like the sea beach. The roof was thirty or forty feet high, the temperature was mild and a slight current of air was perceptible, blowing in the same direction as the water. Being without facilities for further exploration, I returned to the surface.*
>
> *The next morning I lowered three four-foot planks to the bottom of the shaft, and supplying myself with lunch, rope, candles and matches, I descended to the bottom, which I thin k is about 600 feet below the surface. I lashed my planks together and made a raft, placed two lighted candles on it and let it go on the end of a rope. In this way I learned there were no falls in that distance. I continued in this manner for two miles. In this distance I met no obstacle, only here and there where the tunnel cut through a hard formation there would be rocks projecting to the water's edge, but not preventing me from walking over them.*
>
> *The average width of the stream is about 100 feet, and from bank to bank is over 200 feet.*
>
> *The next morning I explored the tunnel up stream. After going a short distance I found a small stream running into the main stream. In it I saw some fine looking fish, and succeeded in landing one with my pole pick. It was a trout eight inches long. I continued until the current of wind got so strong I could not keep my candle burning, so I was compelled to return.*
>
> *"The place where the discovery was made is Gabb's Valley, Nye County, about twenty-five miles northeast of Luning.*

Kokoweef Peak, California

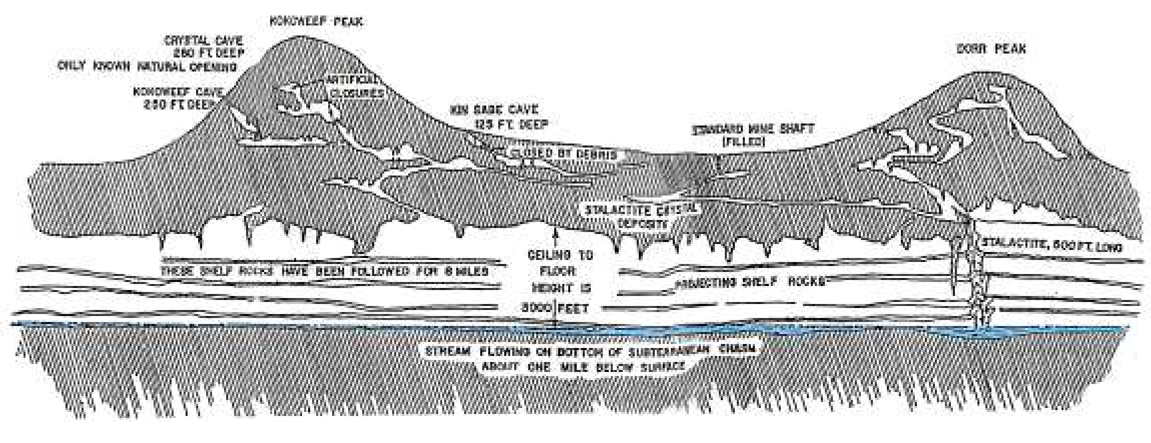
An oft-recounted tale a western underground river stems from Mr. Earl P. Dorr, whose sworn affidavit describes vast caverns near Kokoweef Peak in California's San Bernardino County. Portions of Dorr's testimony stemming from 1927 follow.

> *These caverns are about 250 miles from Los Angeles, California. Traveling over state highways by automobile, the caverns can be reached in a few hours.*
>
> *Accompanied by a mining engineer, I visited the caverns in the month of May 1927. We entered them and spent 4 days exploring them for a distance of between 8 and 9 miles. We carried with us altimeters and pedometers, to measure the distance we traveled, and had an instrument to take measurements of distance by triangulation, together with such instruments convenient and necessary to make observations and estimations.*
>
> *Our examinations revealed the following facts, viz:*
>
> 1. *From the mouth of the cavern we descended about 2000 feet. There, we found a canyon which, on our altimeter, measured about 3000 to 3500 feet deep. We found the caverns to be divided into many chambers, filled and embellished with the usual stalactites and stalagmites, besides many grotesque and fantastic wonders that make the caverns one of the marvels of the world.*
> 2. *On the floor of the canyon there is a flowing river which by careful examination and measurement (by triangulation) we estimated to be about 300 feet wide, and with*

> *considerable depth. The river rises and falls with the tides of the sea -- at high tide, being approximately 300 feet wide, and at low tide, approximately 10 feet wide and 4 feet deep.*

Sworn by E.P. Dorr, 309 Adena St., Pasadena, Calif., November 16, 1934.

The cross-section by Herman Wallace Jr. provided some geologic particulars. Dorr claimed to have dynamited the cavern entrance to protect the secret in 1927. He died in 1957 as a result of a mining accident and his cave's never been rediscovered.


KOKOWEEF PEAK
CRYSTAL CAVE
280 FT. DEEP
ONLY KNOWN NATURAL OPENING
KOKOWEEF CAVE
250 FT. DEEP
ARTIFICIAL CLOSURES
KIN SAGE CAVE
125 FT. DEEP
CLOSED BY DEBRIS
STANDARD MINE SHAFT
(FILLED)
DORR PEAK
STALACTITE CRYSTAL DEPOSITS
CEILING TO FLOOR HEIGHT IS 3000 FEET
STALACTITE, 500 FT. LONG
THESE SHELF ROCKS HAVE BEEN FOLLOWED FOR 8 MILES
PROJECTING SHELF ROCKS
STREAM FLOWING ON BOTTOM OF SUBTERRANEAN CHASM
ABOUT ONE MILE BELOW SURFACE

There's even a “fact based poem” by Ralph E. Lewis, "Underground River of Gold Legend -- Kokoweef Peak or 'Coco-wee-pah?'” We excerpt the lines dealing with the river.

Earl’s signed Affidavit described the caves,
2,000 feet down, down, down they went
They only planned on two days,
In all, four were spent.

They walked along black-sand ledges,
Surveying the vast golden extent.
This was an underground slot-canyon!
Along it 8 miles they went.

There’s a stalactite at the canyon pit,
Earl swears it’s “1,500 feet long,”
A 3,000-ft waterfall washes over it,
Playing his lovely “stream-of-dreams” song.

There’s the ‘river-of-gold’ at the bottom
And it rises and falls each day,
Unknown tons of gold really got ‘em!
Made by John Herman’s single assay.

Today, five acres of private property just northwestern of the peak is camp for volunteers and investors yet searching for Dorr's entrance.

The Spencer River

Might Nevada's Spencer River be the Rio San Buenaventura? Indeed it might, if in fact the Spencer River actually does exist.

"Ghost Towns, Mining Camps & Haunted Sites of the Old West," an internet posting by Dustin Dudley, tells us,

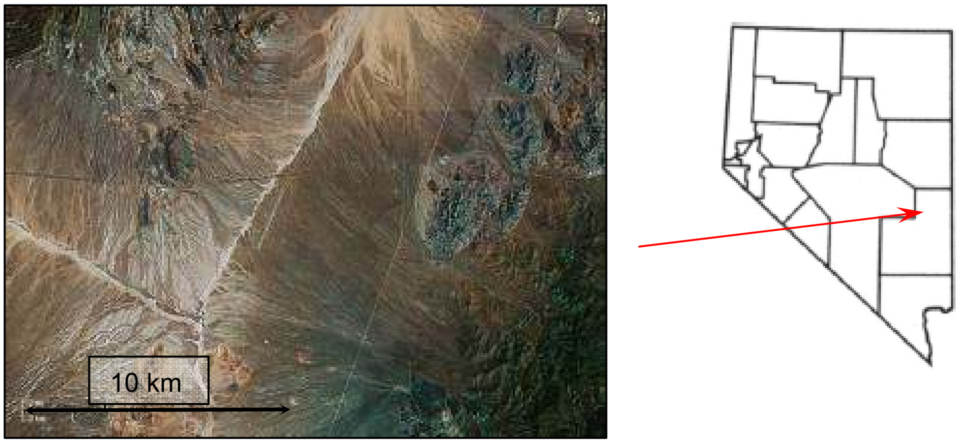
> *A retired rocket scientist living in Nevada claims he has found a currently undiscovered underground river in the Nevada desert. This river, he says, has one and a half times the flow of the Colorado River. If this is true, this water could help supply the whole southwest U.S. Before you laugh, listen to the story.*
>
> *Wally Spencer left his position as a rocket designer to pursue oil exploration. He used several images from space shuttle flights. Wally discovered what he believed to be an ancient riverbed in the southern Nevada desert... He guesses that the start of the river is probably in British Columbia. He figures this due to the fact that British Columbia is littered with underground rivers and lakes. He figures that two or more of these underground rivers merge together as they approach Nevada. He thinks that this river meanders its way into the Pacific Ocean.*

Spencer applied in 1994 to the Nevada Department of Water Resources (NDWR) to appropriate 782 cubic meters/second of water from a source described as the "Spencer River, an underground river flowing in distinct channels."

Employing satellite photos, space shuttle imaging radar which can detect limestone, sand and calcium deposits, and a radiation detector mounted on the back of a pickup, Spencer claimed to have traced the river for ten kilometers.

Spencer speculated that the underground river is probably 500 million years old, flows to the Pacific, and is 1200 meters below the surface, except a reach in Nevada where it's only 114 meters down.

The underground river's location is supposedly a secret -- "90 to 100 miles from Las Vegas," according to business partner Beverly Jacob -- but the drilling locations are NDWR public record.



Spencer asked for a drilling moratorium by others within 32 kilometers of his location and a finder's fee of what amounts to somewhat less than one percent of the water's market value, but only if 2 cubic meters/second were exceeded. The water from the Spencer should be shared with the public without additional cost.

So let's look at the numbers.

	Spencer River	Colorado River
Discharge, cubic meters/second	782, permit application	421, annual average at Lees Ferry
Power	900,000 kW, constant pumping, assuming water table at 114 meters	466,000 kW, Hoover Dam average production

The Spencer River would become the American Southwest's greatest water resource. Phoenix, Las Vegas and Los Angeles and turn on their lawn sprinklers!

Spencer applied for 15 drilling permits, but, assuming that two more Hover Dams could be tapped for the pumping power, in the order of 2,000 more would be required to lift the flow to the land surface.

"Pay Dirt, Underground River to Quench the West" in Equinox, October 1994, was somewhat skeptical, however.

> *You won't find Spencer River on any map of North America -- at least not yet. But it is already flowing for Wally Spencer, a retired chemical engineer who claims to have discovered the major waterways hundreds of meters beneath the Nevada desert. What's more, he says the source could be subsurface caverns in British Columbia.*
>
> *Underground rivers are formed when groundwater enters lava tubes or caverns carved in ancient limestone. But according to Terry Katzer, director for research for the Las Vegas Valley Water District, extensive channels would probably have been disrupted my millions of years of earthquakes and other geological processes. Experts in British Columbia, meanwhile, are equally doubtful. "We are blessed with an abundance of groundwater," says Al Kohut, a specialist with B.C.'s Water Management Program. "But whether there's a connection is more than unlikely."*

And back to "Ghost Towns, Mining Camps & Haunted Sites of the Old West,"

> *The government is trying to sort everything out right now. They are trying to decide who gets what, if an agreement can be reached. The government now knows that they will not find out where the subterranean river lies unless an agreement is made. They have tried everything to find out. Wally has had bugs (listening devices) planted in his house numerous times by unknown government agencies. He knows better than to ever talk about the location of his find. He is just waiting for the day when everything is settled and he can drill for his water. He*

> *is now in his seventies and who knows, if an agreement is not made sometime in the near future, he may take this information to the grave with him.*

"To the grave" seems to be the outcome, as Spencer died in 2003 at age 73.

But maybe not. Failing to submit evidence of sufficient water to support the application, NDWR rejected the application in 1999, but Spencer's widow is protesting the ruling.

Western underground river stories are not unrelated, of course, as revealed on TV's "Unsolved Mysteries," October 13, 1993, the story of Dorr and Spencer. The latter feared for his life from the unknown parties who bugged his residence to maintain their water monopolies.

UNSOLVED
mysteries

Prospecting in the 1920s

Dorr going underground

Discovering the underground river

Destroying the entrance

Clues from satellite

Spencer locating the river

Discovering the surveillance bug

Don't let on that we're aware

It's in the Paper,

Most Americans don't regularly receive the news from a fact-checking source; they garner bits and pieces of information from whatever media they happen to come upon for whatever reason. Political campaigns are based on this model.

The problem is compounded when lower-echelon media entities themselves uncritically propagate such information. "The Proposed Yucca Mountain Repository: Who Could be at Risk?" Pahrump Valley Gazette of August 12, 1999, serves as a case in point.

The most read newspaper in Nye County

Pahrump Valley Gazette

> *Two events document the existence of a large underground river in the vicinity of the proposed repository. One possible source of the water for this underground river was discovered when the Navy was unable to explain the discrepancy between the surface water entering Walker Lake and the volume of water retained in the basin. The deficit at first appeared to be a loss to an unknown aquifer.*
>
> *Using massive amounts of dye, the water was traced to its destination which was in the Sea of Cortez east of Baja California. This of course does not establish the route, only its point of origin and its eventual destination.*
>
> *The second event places the possible route near to the area in question and involves a gruesome event, which occurred at Devil's Hole near Ash Mountain and 30 some miles south of Yucca Mountain.*
>
> *A solo scuba diver in Devil's Hole apparently became entangled in some underwater passageway. He apparently undid the straps holding his air source and became separated from the lifeline. The result was disastrous. His body was never recovered. His air bottle (traced by serial number) was found sometime later when it surfaced in the Sea of Cortez.*
>
> *These tow events tend to prove that an underground river does exist and passes near the Nevada Test Site and the proposed Yucca Mountain repository...*
>
> *Forty years ago Shell Oil exploration in the vicinity of Arden, Nevada (as related by a person living in Las Vegas at the time) intersected an underground source of water with a massive force causing the deflection of the well casing preventing installation. This stopped further exploration and penetration of the earth's crust. Could they have intersected the route of the underground river which connects Walker Lake and Devil's Hole?*
>
> *Another legend which may point to the route is that of the Indian cave on Kokoweef Mountain near Mountain Pass. The legend tells of an underground river larger than the Colorado which is below sea level and is found in a massive cavern with an underground bluff some 1,500 feet above and overlooking the river channel. (An earth tide is also noted affecting the water level. The rate of water flow from Cima Springs also appears to be associates with ocean tides. It is related to the pulsing of the earth's mantle above the caldron of gasses and molten lava.)*
>
> *Is the Kokoweef legend true? A 1960 participant in a group which included the owner of Culligan Water related that seismic exploratory tests indicated a gigantic cavern deep within the bowels of* this formation.

The piece spews nonsense, 5000 copies in newsprint, to give it a number. We've a missing body, an air tank bobbing up off Mexico, the Navy, Shell Oil and Culligan Water, dimensions of a cavern cliff, a subterranean current sufficient to bend heavy pipe.

Is it any wonder that not a small group of Nevadans envision a mysterious, perhaps monstrous, river beneath their feet?

And Again, the Rio San Buenaventura

Earlier in this chapter, we took the explorer John Fremont at his word, relegating the Rio San Buenaventura to a fabrication that hooked many a mapmaker. A southward-flowing stream toward the San Buenaventura Mission was given the name, but no one pretended it to be the fabled waterway.

As for the San Buenaventura Mission, however, we have an item of interest from the Ladies' Repository, April 1874.

> *Subterranean Fishes. At San Buenaventura, in California, not long ago, an artesian well was sunk on the sea-beach, about five feet from high-water mark. At the depth of one-hundred and forty-three feet, a strong flow of water was obtained, which spouted to the height of thirty feet. One day, fish were observed in the waste water around the well. On examination, the well was found to be filled with young trout, a large number being thrown out at every jet. They were perfectly developed, and about two inches long. The first examination was to see if they had any eyes; these were found to be perfect. Now, there was no stream within a distance of several miles; and that one, Santa Clara River, had no trout in the lower portion of it. The fish, therefore, must have come from the headwaters of this stream, through some subterranean outlet.*

Consider the facts:

1) A legendary river lost in the Great Basin.
2) A fish-laden fountain emergent at the California mission of the same name.

Can we not but wonder if the trout were Utah cutthroat? Pursuit of underground rivers is all about possibilities, is it not?

Conclusion

The Rio San Buenaventura was elaborated by a generation of mapmakers, but in the end was discarded by frustrated explorers and topographic reality. To preserve itself, even the best of legend requires at least a hint of physical corroboration.

Clues to the river's subterranean existence are more difficult to jettison, however. If what we've unearthed -- somewhat literally -- about such an underground river fails to satisfy our scientific skepticism, we've Chapter 88 yet to come, Extraterrestrials and Lost Races of the American West, where evidence for the hidden river will be furthered. Astonishingly furthered.

CHAPTER 87

THE PARANORMAL

Paranormal:	Phenomena outside the range of normal experience.
	Phenomena inconsistent with the world as conventionally understood through empirical observation and scientific methodology.

To the degree that observation of underground rivers is consistent with a well-established Newtonian framework, they are not paranormal.

Should such waterways, however, manifest characteristics -- energy fields, in our particular case -- inconsistent with what we consider to be normal science, the subject becomes that of the paranormal.

The conceptualization of underground waters before the Scientific Revolution -- and sometimes well past it -- included divine will, alchemism and odd geophysics, but such ideas weren't in opposition to the prevailing world view. It is not content, per se, that makes a particular belief paranormal, but rather it is the adherence to the belief in the face of convention that makes it so.

Chapter 46, Finding the Underground Rivers, drew upon perceptual senses outside of the tent of standard science to describe groundwater dowsing. We might thus have postponed that topic until the present chapter, but we thought it better to include it in a chapter related to objective.

In Chapter 88, we'll touch on alleged extraterrestrial beings beneath the American West, beings with abilities perhaps scientific to them, but paranormal to us.

In this chapter we'll look at the paranormal in three other settings.

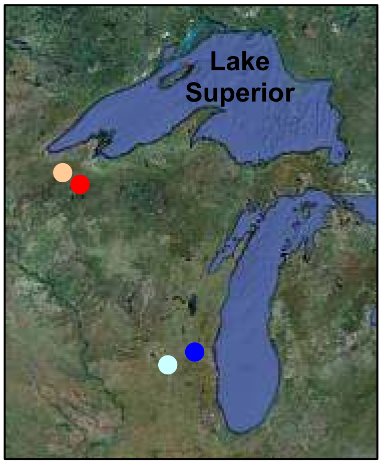
> We'll briefly touch upon a few underground river stories of the paranormal that most everyone would agree are just tall tales.
>
> We'll spend a bit on time in London where reports of the supernatural have been grouped by location, and yes, proximity to underground rivers does appear to be a factor.
>
> And lastly we'll look at alleged paranormal energies of subterranean waters and its pseudoscientific justification.

Wisconsin, though it could be most anywhere

Anecdotal tales abound regarding underground rivers and the paranormal. They're just stories because they pretend to be nothing else.

To exemplify, we'll summarize three from Wisconsin.

- ● Bottomless Lakes
- ● Lake Geneva
- ● Red Cedar Lake
- ● Lake Ripley



1. The "Bottomless Lakes" near Honey Creek are said to be to be similar to Lake Superior, having these aspects in common.

   Lacustrine monsters
   Unique fish
   Big Foot sightings
   Strange lights
   Indian mounds

   We've a meld of campfire-yarns and fanciful interpretations of local attributes. We recognize the fish claim as the subterranean river hypothesis in Chapter 78, Beneath the Great Lakes. The Indian mounds predictably point to lost civilizations (Chapter 88) which, given the region's other inexplicabilities, perhaps yet ominously dwell below us. It's underground river territory in more than a geographic sense.

2. A young man dumped his car into Lake Geneva while trying to evade police. The car and could not be recovered. The boy's parents contacted the crew of Jacques Cousteau who brought a small submarine with which they discovered an underground river flowing from the lake. They were almost sucked in. This river comes from Greenland, under Lake Superior to Wisconsin, then west to Nevada, out under the Pacific to Malaysia, up under Europe and back to Greenland. How many such lakes are in the area is unknown, but there are at least three.

   We've the enticing detail of "while trying to evade police," the unreferenced authority of Jacques Cousteau and the mysterious global underground river that paranormally circles back to its source. People may believe portions of the account, but packaged together, it becomes just another spooky tale.

3. In 1890, a farmer claimed to have seen a 12-meter serpent carrying one of his hogs into Red Cedar Lake. In 1891, a fisherman tying up his boat saw an undulating serpent, its body like that of a snake. The head he could not see. Farmers and other fishermen claimed to have also observed the creature; one stated that it had a large head with "protuberances like saw teeth" on its 15-meter back. The serpent was blamed in 1892 for partially devouring five sheep belonging to William Ward. Fears were so severe that residents of nearby Lake Ripley, joined to Red Cedar Lake by an underground stream, closed their summer cottages and returned to the city.

   Such a monster is paranormal by simple definition; 12-meter livestock-eating serpents are not normal. As noted in Chapter 80, To Lie Like a Mulhatton, 19th century journalists enjoyed a good hoax.

   The allusion to the underground stream, however, doesn't, per se, read as part of the fabrication. Them Lake Ripley city-folk -- har, har, har! -- bit on the serpent story. Everybody knows that Willie Ward enjoys his bottle, right? But, you know, if there is such a creature down there, it might have a way to get places.

London Hauntings

In looking for ghosts, it's to our advantage that others have already done so, and unlike most writings regarding to the supernatural, some of their efforts can be reviewed.

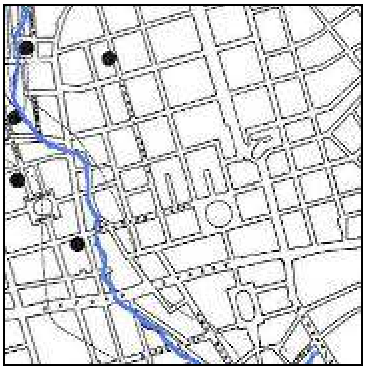
According to G.W. Lambert in "The Geography of London Ghosts," Journal of the Society for Psychical Research 40:7, December 1960, approximately three quarters of the city's paranormal activity takes place near buried waters.

But does the 75 percent signify a primary relationship?

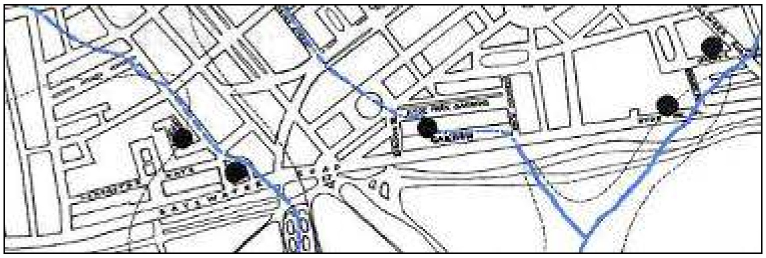
We'll quote a few portions of the work.

> *The Society's records of cases of haunting and poltergeists number several hundreds. For London alone, they amount to just over one hundred... To deal in detail with the whole of that area would draw out this study to tedious length, and tire the reader. I will therefore take first a sample district, furnishing enough cases to suggest a working hypothesis, and then apply that hypothesis to two other districts, to see if it works there also.*

The study identifies the underground river courses and ten haunted dwellings in postal district W.1. Locations are to the right



The study then sites three underground river courses and eight haunted houses in postal district W.2



> *To sum up, five (i.e. over 50%) of the cases in W.2 fall in a narrow rectangle bounded on the south by one mile of the Bayswater Road, from Marble Arch to the middle of Lancaster Gate, and about 220 yards wide from south to north. This is rather less than one eighth of the area of W.2. That grouping can hardly be a chance effect.*

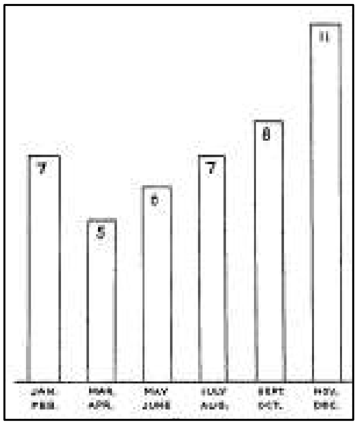
The study then describes the underground rivers courses and locations of 100 haunted houses in postal district S.W.2

> *Of the total of 100 cases, 85 are north of the Thames and 15 south of it. Of the latter group as many as six are in Battersea, the remainder being very scattered. The Battersea cases seem to follow the course of an old creek, now in a brick culvert underground, reaching from near Nine Elms, round by the foot of Lavender Hill, to near the outfall of the Falcon Brook.*

While we might suggest a better statistical design, we'll grant the correlation; where there are buried rivers, there's a disproportionate number poltergeists.

The study then considers the incidence of rainfall.

> *It is noticeable that some seasons of the year are more prolific of cases than others. In order to illustrate this, I have taken 44 cases from the whole collection, which can be sorted by month as well as year, and have shown their incidence by two-monthly periods in the following diagram.*
>
> *The preference for the autumn and winter months (September to February, inclusive) is obvious. There is also a summer peak in July-August, the season of thunderstorms. It can, of course, be argued that in the winter people are longer indoors and have more opportunities to observe unaccountable incidents, but that would not explain the summer peak in July-August, months during which people generally are more out of doors than at any other time ' of year.*



> *The two kinds of evidence advanced above relate to the distant ends of the chains of events which, on the working hypothesis, lead to the events to be explained. In each case the chains go underground, in the literal sense of that expression.*
>
> *The circumstantial evidence in more than one case suggests that underground rivers in flood sometimes discharge water under pressure into old disused house drains, the branches of which to each house were sealed off (inside the perimeter) when a new system was introduced.*
>
> *It is not too much to claim that the time has now come to look for further detailed observations in the most likely quarter, namely underground, and no longer to jump to the conclusion that all is lying, trickery or "psychic" agency.*

In a nutshell: Ghostly apparitions do indeed appear to concentrate in the vicinity of buried rivers, Lambert goes a step further by introducing seasonality as an independent variable. Hauntings seem to happen when it's raining and flooded storm sewers would be prone to disturb the foundations of buildings above.

Thus what the London tourism industry advertises as haunted houses might likewise be described as urban buildings on wet foundations.

Discovering the city's best kept secrets
HAUNTED
RICHARD JONES
LONDON

Not all paranormal allegations, however, can be as objectively evaluated.

Earth Energies

Throughout our subterranean river journey, we've endeavored to quote directly from sources. If we've clipped some excerpts too severely, at least we've provided a reference.

Dealing with the paranormal, however, studies such as Lambert's are excruciatingly rare. Publications are many, but tend to be of the supermarket-checkout-stand variety and cut-and-pasted web pages. References to original sources are nil, and sadly to say, the few claims sporting an authoritative ring too often turn out to be unverifiable.

The remainder of chapter thus has a bibliographic problem. We'll dutifully pass along what's said, but rarely can we trace the genesis of the claim with any degree of confidence.

An example, a claim asserted in nearly-word-for-word manner without elaboration on numerous web postings:

> *This type of energy line* [one that emanates form a subterranean stream] *is easily detected by a skilled dowser. It can also be detected by a German analytical instrument developed by Dr. Ernst Hartmann and Dr. Dieter Ashcroft in Essen. This equipment known as the Genitron Felix-3 detects ultra short and radio microwave frequencies with the ability to print them out on a UKW- Spektrometer und Linienschreiber. This equipment is used in German universities and research institutes*

As a machine such as the Felix-3 would seem applicable to a variety of underground river studies, we've done a bit of internet shopping.

Genitron, now part of the Saphymo Group, is indeed a European corporation that produces high-tech detection equipment, but the firm markets no Felix-3 or similarly-named or purposed apparatus.

The only Felix-3s (alternative spellings checked as well) returned by internet search are those of the same story.

No university or institute, German or otherwise, indicates a device by that name in their laboratory capacities.

Ernst Hartmann (1915-1992), the co-inventor, was a medical doctor and dowser who made known in Krankheit als Standortproblem (Illness as a Location Problem, 1960) that illness depends on one's location on the earth's "Global-Net Grid," now known as the "Hartmann Grid." There's no mention in his biographies of an engineering invention, but if, in fact, he carried around an impressive black box with wires and lights, there's every reason to challenge its impartiality.

Dieter Ashcroft, inferentially also a notable inventor, is absent from German scientific records.

Absence of internet corroboration does not prove the Felix-3 to be fictional, of course, but the device's absence challenges the credibility of the rest of the citation.

Genitron markets many instruments, but no Felix-3.

But then again -- the bane of this type of fact check -- nefarious government and multinational corporations may have colluded to confiscate all Felix-3s.

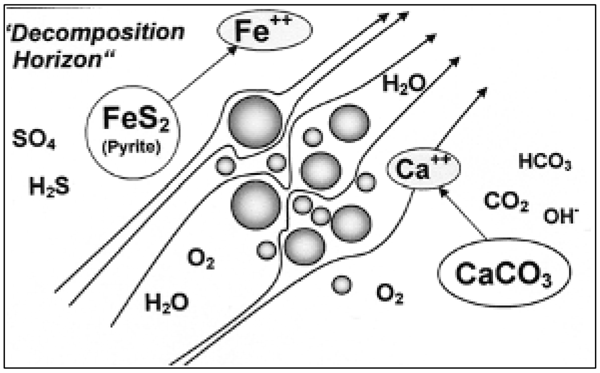
Which is to say that, alas, that we can do little more than pass along what has been repeated by those who've seen the Felix-3 mentioned. The rest of this chapter suffers the same problem.

The Pseudoscience

We established in Chapter 8, Subterranean Engines, that water has electromagnetic properties, but not enough for geomagnetic force to propel it to mountain springs. But here we ask another question. Does subterranean water have "subtle energies" that might influence those of us who live above it, energies too subtle to be recognized by scientists paid by the government?

A subtle field is said to be a vortex composed of two spiraling bands, one positive and the other negative, the former carrying the charge and the latter being neutral. (We must quit trying to make sense of this in terms of electrons and such. This is newer.)

Water flowing through anisotropic ground takes up solutes such (e.g. calcium carbonate and pyrite) and metallic ions which induce dynamic broadband resonance. Being a dialectic medium, water favors the formation of potential vortices which contract swiftly after formation. Rotating the dipolar water molecule changes the field composition and the hydronamic flow vortex is produces an electromagnetic vortex and eddy current.



We're unsure of the meaning of "hydronamic," but does it matter?

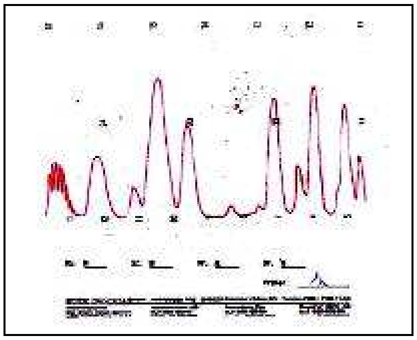
Subterranean water flow generates the following, depending on speed and solutes:

A positive vertical direct-current electromagnetic field
Radio frequencies ranging from 87 to 101 MHz
Microwaves in the 6-centimeter band at the edges of the stream

Additional power is gained where decrystallization occurs. Where streams cross, one above the other, the field becomes more complex.

Below is evidence of the microwaves.

Photographic print of microwaves radiating in the space above an underground watercourse taken in total darkness.

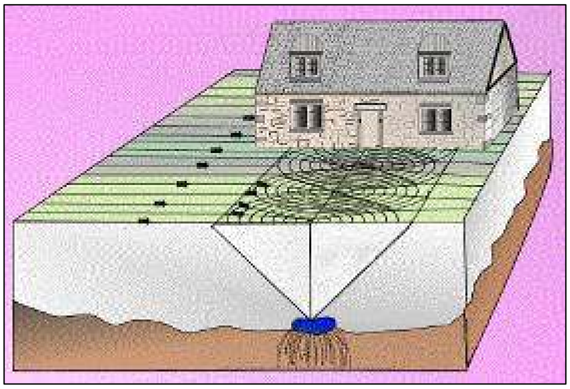


Frequency of the energy emanating from an underground stream recorded by Genitron Felix-F3 frequency analyzer, an apparatus discussed earlier.

We're unsure of what's being shown, but it indeed looks scientific.

Geophysical Manifestations

"Black streams," underground water veins that emit radiation, are evidenced as earth meridians whose flow has become stagnant or polluted, emanating "Sha Qi" to the surface above. The black stream may be from 0.3 to 1000 meters deep and 0.3 to 100 meters wide. When dowsed, the edges and the centerline are the sharpest. Where the underground channel rises, the edge lines are the more active; on the descent, it's the centerline.

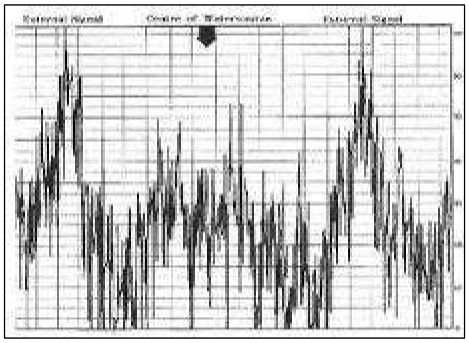


Black streams may have tributaries, convergences, and dowsable echoes parallel to the main stream. They may change course, especially after earthquakes and droughts. They are known to be stronger at midday, mid-summer, full moon, and during periods of sunspot activity. They are also known to be associated with higher levels of ionizing radiation and lightning strikes.

The figure shows how earth energies radiate at 45 degrees from an underground stream, forming vortices on the surface.

As David R. Cowan's internet posting, "Divining and Dowsing, How to use Divining Rods to Find Earth Energies," explains,

> *Concentrate on finding an underground stream and you should find the central wave first, directly above the flowing water. Place a marker over this. The rods will also tell you the direction of flow. Then walk on at a right angle to the stream until the rods react again at one of the outer parallels. Here place another marker. The distance between the markers is the same as the depth of the underground water.*
>
> *This is a simplification of the procedure, since there are said to be other wavebands inside and outside of the parallels, also produced by the running water. It is by finding these that experienced water diviners can judge how much water there might be in an underground course.*



To the right is the earth energy field at the "External Signal," the "Centre of Watercourse" and again at the opposite "External Signal." If there is sufficient energy to drive the pens, however, we question if such energy could be classified as "subtle."

But such earth energies are not solely the product of watercourses.

The "Hartmann Grid" consists of naturally-occurring charged lines running North-South every 2 meters and East-West every 2.5 meters. Alternate lines are positively and negatively charged, so where the lines intersect it is possible to have double positive charges and double negative charges. A subterranean stream intersection with a Hartmann grid can cause a severe "Hartman knot."

The Mystery of the White Lions: Children of the Sun God, (2010) is author Linda Tucker's account of her journey into the guarded knowledge and ceremonies of Old Africa. According to the spirit guide Amarava, the last of the first people, water is not native to earth. Rather, the Milky Way is the "spinal fluid" of the universe. "A lot of water is carried between the stars, and is distributed across space this way."

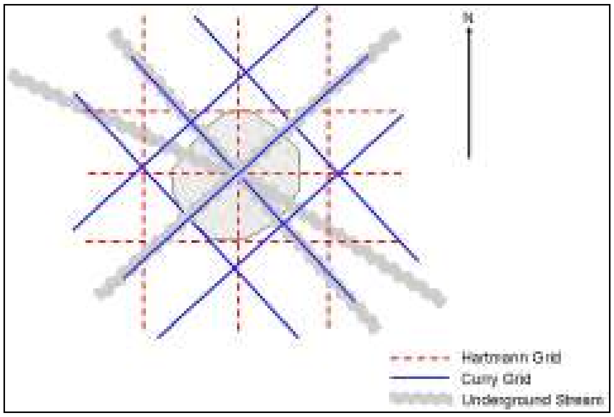
In the chapter entitled, "Underground River of Gold" we're told of the Lulungwa Mangakatsi, "river of the stars" and "the river that never runs dry," a parallel between the Egyptian "duat" linking "river in the sky" and "subterranean river." The Lulngwa Mangakatsi holds Africa together by the power of Ley Lines. ”The next time you find a flowing river in the veld (bush), go at night, with leather soles to that river. The nearer you get to the river, the more you will feel this thing, this vibration.”

Fresh water rivers are living things containing memory which shaman can read. Where such rives intersect with underground rivers, great pipes of invisible power result.

Is there a "power line" underground river of energy linking the Timbavati with Giza? According to Amarava, yes.

There is also the "Curry Grid," but we've already ventured too far on this tangent.

According to Earth Energy, The Impact of Earth Energies on Life, An Overview of the Origin of Earth Energies, The Hartmann & Curry Grids, undated, by Jiro Olcott, the Menhir de Champ-Dolent -- more than 10 meters high, one of the largest standing menhirs in Brittany -- is precisely at the intersection of Hartmann and Curry Grids as well as no less than three underground streams.



Le Menhir de Champ-Dolent showing crossing points of earth energy currents and underwater streams

Having unconvincingly explained how hydro-electrochemistry excites geo-energies, we now move to biology. If there's one thing to be learned from the literature of the paranormal, it's to look for linkages.

Human Health Effects

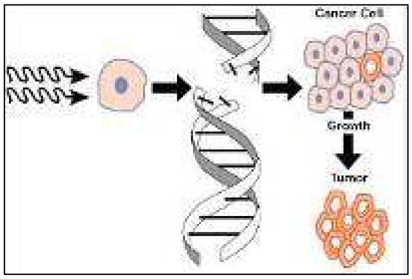
We turn to WhiteMagicWay.com.

> *The geobiology elements are earth meridians, underground water veins or lakes and underground geological cracks or cavities and earth-sky chimneys. These elements emit frequencies above the earth surface that influence living organisms.*
>
> *The human being is an antenna between earth and sky. Its feet are connected to the negative pole, the earth; its head is connected to the positive pole, the sky. Permanently submitted to energy exchange between these two poles, the earth sky flow nourishes its body energetically, for its survival.*
>
> *When two bodies have similar wave length and frequencies, they have instant communication through resonance no matter what the distance is between them.*

> *Earth is a living being with elements similar to our body; it has 70% of water, it has chakras, meridians, veins and articulations and subtle bodies. That is why our body communicates with earth through resonance.*

The living-earth analogy of course goes back to Aristotle.

The carcinogens consequence of underground stream energy is illustrated to the right.


Cancer Cell
Growth
Tumor

Reported effects of sleeping on the outside edge of an underground watercourse include

Hypersensitivity to light
Insomnia
Fatigue and loss of vitality
Premature aging
Degenerative diseases and rheumatism
Depression headaches
Short term memory loss
Loss of balance
Panic attacks
Optimistic abnormal cell growth leading to cancer

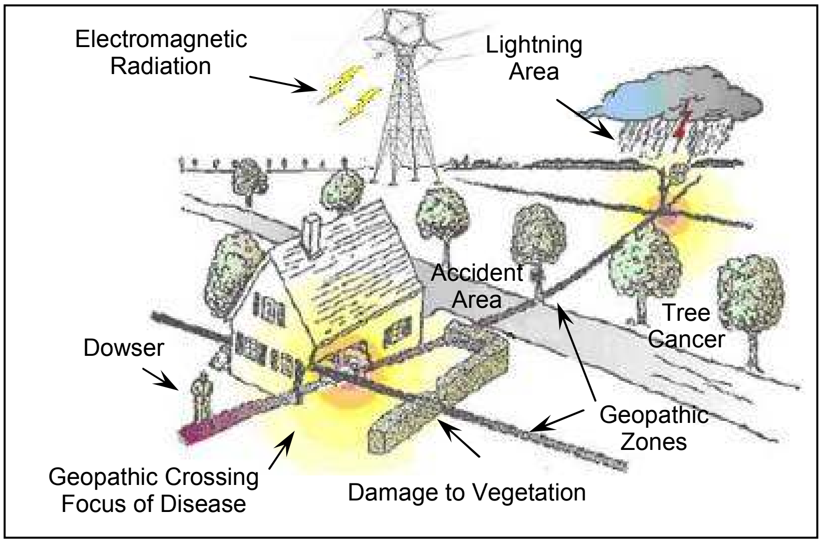
The edge lines are found to be more associated with physical diseases, while the center lines have more correspondence to mental and psycho-spiritual disturbances.

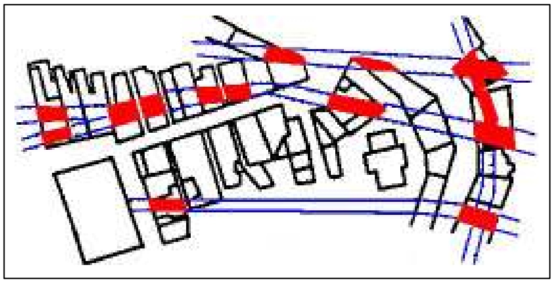
There may also be enhanced production of microbes encouraging mould and rot.

According to Effects of Harmful Radiation and Noxious Rays (1974) by the American Society of Dowsers,

> *In addition to disease in humans, animals and plants, it has been observed that auto accidents repeatedly occur at points where veins of underground veins run under roads and highways.*

The sketch is said to be of a German location.


Electromagnetic Radiation
Lightning Area
Accident Area
Tree Cancer
Dowser
Geopathic Zones
Geopathic Crossing Focus of Disease
Damage to Vegetation

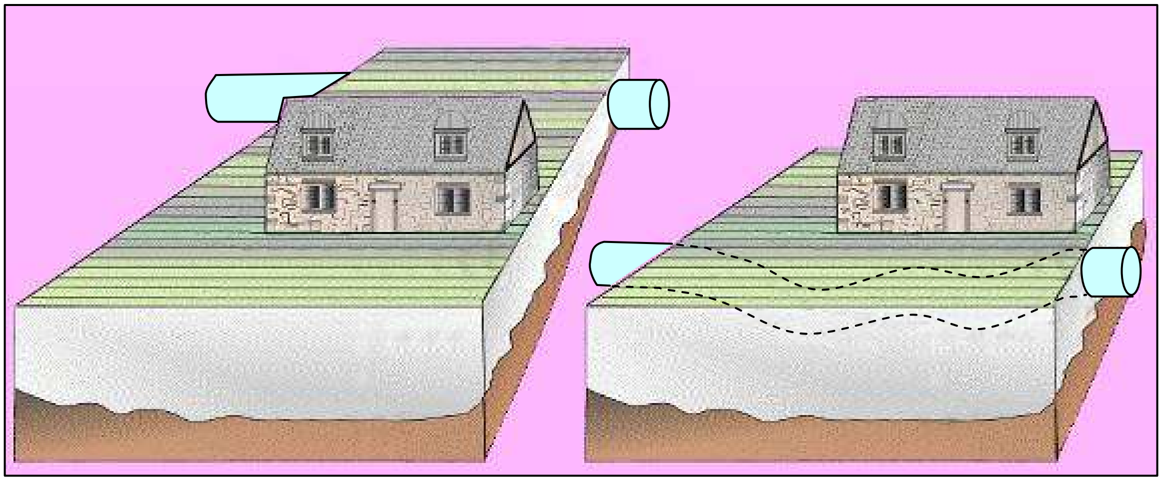


The map to the right is said to be of a German town. Blue lines indicate underground water. Buildings marked red experienced at least one case of cancer in a period of 20 years, according to a German doctor.

Those who seek correlation between underground rivers and deleterious health effects will indeed find one significant relationship: the reports tend to come from Germany.

Feng Shui rules regarding subterranean waters:

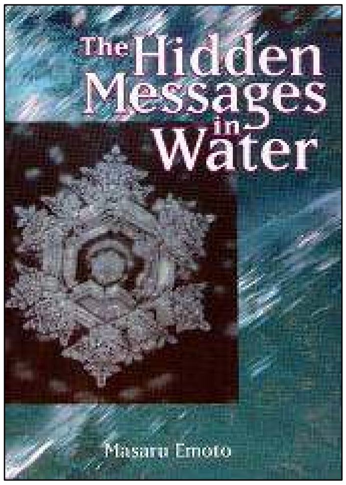
1: Avoid a building site with subterranean streamflow behind the house.
2: Avoid a building site situated near a straight subterranean watercourse.



Bad Good

But according to Alen MacWeeney and Caro Ness, whose A Space for Silence (2008) promotes sacred spaces for relaxation, meditation and reflection, perhaps it's not all bad.

> *Water lines: Underground streams undulating beneath the earth surface and creating a vertical electromagnetic field several feet wide which is yin in energy and thought to be enervating.*



We've consider only paranormal radiations derived from the geosystem, but who's to say we ourselves don't energize what's beneath our feet?

Masuro Emoto's Hidden Messages of Water (2005) argues that human consciousness has an effect on the molecular structure of water, causing it to carry emotions and thoughts.

When we have deep, emotive thoughts -- and its human nature that we do -- we thus may be energizing subterranean streamflow?

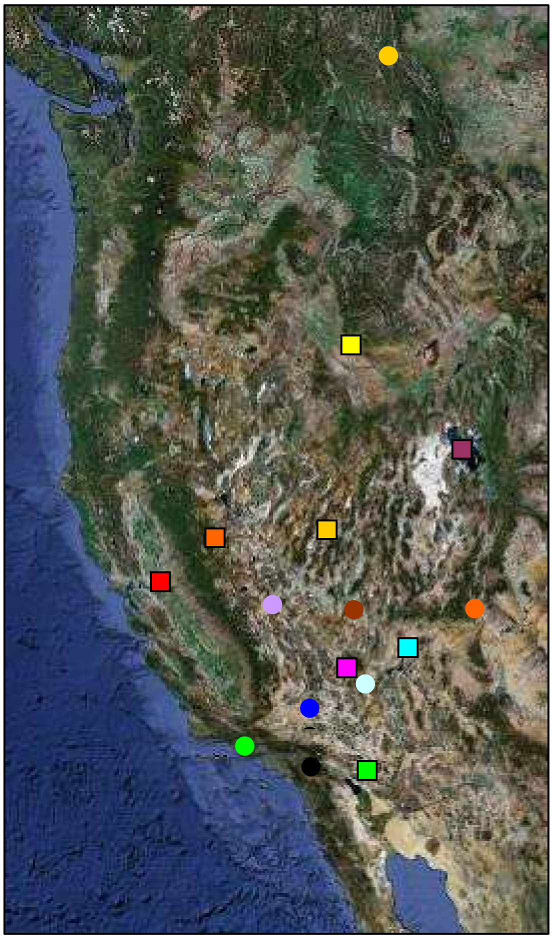
CHAPTER 88

EXTRATERRESTRIALS AND LOST RACES OF THE AMERICAN WEST

Chapters 16-25 brought us a menagerie of imagined subterranean monsters, the remnants of Atlantilian civilizations and evidence of extraterrestrials. Admiral Byrd's diary (Chapter 14, Hollow Earth Geophysics) was engaging, but fictional.

This chapter isn't about fiction, at least literature marketed as such. We will draw together reports of aliens and vanished civilizations encountered along subterranean waters in the western United States. As the literature of alien visitations and subterranean races tends to intermingle, so will our chapter. Alien visitation from outer space and alien inhabitation beneath our feet have similar likelihood.

As we've done before, we'll begin with a map. Being part of this story, locations from Chapter 86, The Rio San Buenaventura, are indicated by squares.



Chapter 86
- 🟥 Rio San Buenaventura
- 🟩 Southern Branch
- 🟨 Northern Tributary
- 🟨 Nye County
- 🟪 Kokoweef Peak
- 🟦 Spencer River
- 🟪 Great Salt Lake
- 🟧 Lake Tahoe

This Chapter
- 🟡 Northern Rockies
- 🟣 Deep Springs
- 🟤 Area 51
- 🟠 Montezuma's Treasure
- ⚪ Mojave Desert
- 🔵 Camp Irwin
- 🟢 Los Angeles
- ⚫ Devil's Hole

We'll start at the top.

Rocky Mountains

A great underground river in the American West made the news as far away as New Zealand, as evidenced by "The Writing in the Geode," by C.H. Shinn, Tuapeka Times, May 17, 1890.

> *Heart of the Rockies, about September 17, 1886.*
>
> *The entrance to this sub-montane river is in the Assinniboine Mountains, north of the United States line. I was a prospector there for several years, and I heard stories among the older Indiana that a river greater than the Columbia had once flowed where the Rocky Mountains now are; that the Great Spirit had piled the mountains over it and buried it deep underground. At last a medicine man, whose life I had once saved, told me that he knew how to get to the river, and he took me into a cave in a deep gorge. Here we lived for a week, exploring by means of pine torches, and at last found a passage which ran steadily downward. This, the Indian told me, was the path by which his ancestors, who once lived in the middle of the earth, had found their way to the light of day.*
>
> *I think we were about three thousand feet below the entrance of the cave, when we began to hear the sound of roaring waters. The sound increased, until we stood by an underground river, of whose width and depth we could form no idea. The light of our torches did not even reveal the height of the roof overhead. My guide told me that this was the mother of all the rivers of the world. No other person except himself knew of its existence. It flowed from the end of the north to the extreme south. It grew ever warmer and warmer. There was a time when people lived along its channel, and there were houses and cities of the dead there, and many strange things. It was full of fish without eyes, and they were good to eat. If I would help him build a raft, he would float with me down this river. The old stories said that one could go upon it for many miles. It ran down a hollow under the mountains.*
>
> *We built and equipped our raft and launched it on the most foolhardy adventure, I do believe, that ever occupied the attention of men. We lit torches, and set them in sockets on the raft, and we were well armed. For two weeks we moved down the high archway, al a steady rate of only about three miles an hour. The average width of the stream was about five hundred feet, but at times it widened out to almost twice that. It swarmed with many kinds of fish, and they were very easy to secure. The rook walls and root seemed to be of solid granite. We were below the later formations.*
>
> *As nearly as I can calculate, we were about a thousand miles from where our voyage began, and nothing had yet happened to disturb its monotony, when we began to find traces of ancient work...*
>
> *Suddenly we found that the river was flowing much faster, and we failed to check our raft. We went over a water-fall, perhaps seventy feet high, and were thrown on a shelf of rock at the side of the river below. I was unhurt, but my companion was so badly injured that he died in a few hours. I repaired the raft after a fashion, and continued the voyage, finding it impossible to contrive any way to scale the sides of the water-fall and attempt a return. All our torches were lost and the attempt to proceed further seemed but a last act of despair. A few hours later, I saw a light gleaming over the river in a very remarkable way, shining clear across, as if from the head-light of a locomotive high up on the wall. This aroused me somewhat from my stupor and misery. I sat up on the raft, and steered it close to the edge of the river to see what wonderful thing had happened...*
>
> *I have lived hero for months, and I have explored all the chambers of the place. There is no escape, so far as I can see. The river, twenty miles below, plunges down vaster descents, and the water gets so hot that I should be boiled alive if I tried the voyage... I am convinced that the river which brought me here flows on into the Gulf of Mexico, and that, sooner or later, my log will be picked up. Perhaps this river is really the source of the Gulf Stream.*

The doomed scribe continues about the artifacts a lost race, but we've not time for the anthropology.

Montezuma's Treasure

A more-recent tale comes to us courtesy of the Southern Utah News, June 27, 1990. Based on a circle with downward arrow carved in a rock, supposedly the Aztec treasure hiding sign for the "water trap," Grandt Child deduced that the hiding place of Montezuma's treasure was in the lower of the three ponds six miles north of Kanab. A colleague made a dive and discovered a 1x2-meter tunnel, handmade in appearance. Approaching the entrance, he was caught in a heavy draft and feared being swept into an underground river. Child wished to drain the lake, but the site unfortunately happens to be habitat to the endangered Kanab Amber Snail, or so the government insists.

The Mojave Desert

Branton is the pseudonym of an American UFO investigator with a background unsurprisingly in paranormal research. Branton's works include the likes of,

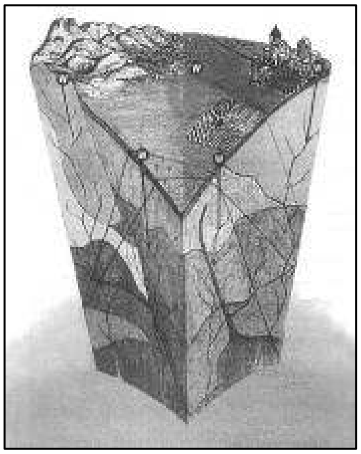
The Secrets of the Mojave, 7th Edition (1995),
The Dulce Wars: Underground Alien Bases and the Battle for Planet Earth (1999),
The Omega Files, Secret Nazi UFO Bases Revealed (2000), and
Reality of the Serpent Race and the Subterranean Origin of UFOs (2003)

As we're more concerned with underground water than underground Nazis, here's an excerpt from The Secrets of the Mojave.

> *The Paihute Indians as we have also related, tell of a race of Grecian or Egyptian-like people with white robes, sandals, and long dark hair held back with a band, who thousands of years ago arrived in North America in large rowing-sailing vessels. The Paiutes say that when Death Valley was still part of an inland sea connected to the Pacific Ocean through the Gulf of California, these "Havmusuvs" discovered an underground cavern system within the Panamint Mountains adjacent to the west edge of Death Valley, and within these vast caverns they built their civilization. To briefly review the Paihute account:*
>
> *The legend says that these ancient people landed their ships near or just below large "quays'" or "doors" high up the eastern slope of the Panamints. However after centuries the lake eventually dried up and disappeared, and as a result of this they developed new methods of reaching the world beyond. This, the Paihutes say, was when they began to experiment with the construction of silvery "flying canoes."*

Bob Fryer, in "Thinking of Water" in The American Dowser, Winter 1990, adds a stratum of geological obfuscation.

> *In the early 50s, a geo-chemist, metallurgist, mining engineer and dowser named Stephan Riess theorized that a vast supply of water ran under the Mojave Desert large enough to supply the needs of all the people in southern California. Riess's conclusions were corroborated by a study done by civil engineers. Their findings revealed that there was as Riess called it, primary water travelling in the deep rock fault system under the desert that had nothing in common with the water in the alluvium sedimentary aquifers. This rock fissure water was also so pure that chlorination was unnecessary, and it ran like deep, life-giving veins in the earth. In fact,* Riess *contended that most underground water did not originate via precipitation that had gradually percolated through the soil as previously thought. Water is incompressible, so once it has reached a depth where the density of the soil becomes equal to its own, it simply cannot "seep" downward any further. He felt instead that the largest quantities of water underground were formed from the elements within the earth, and constituted primary water that had never seen the surface of the earth before. Freshwater springs that spew forth large volumes of water off the coast of islands are good examples.*



The Source of Earth-Generated Water
Earth-Generated Water Well
Water Flowing in Fissures
Crystalline Structures
Cracks in Cooling Rock
Ore Minerals
Grains of Ore Disseminated through Rock

As we paddled through similar aqua-genesis in Chapter 8, we won't go there.

Deep Springs, California

Deep Springs, California lies due east of San Jose. The following account is related by Val Valerian in his December 1989 Leading Edge Newsletter.

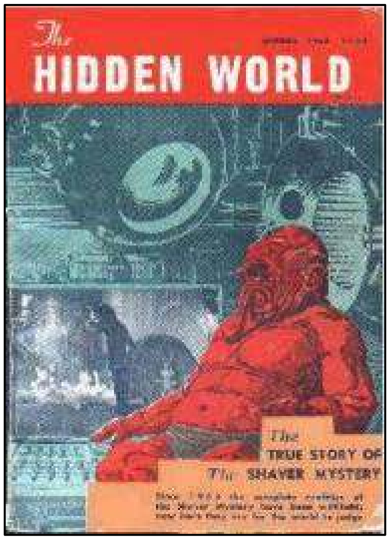
> *Deep Springs, California is an area that is becoming known as the site for very strange events. According to the information released both on the air on KVEG-AM and from other sources, the area is full of strange people wandering around in black suits. There have also been rumors that there is an underground facility in the area. Checking with gravity anomaly maps proved that there are large cavities under the ground in that area. The wildest claims relative to the area have stated that alien life forms are being released there... Deep Springs Lake has been probed and it appears bottomless. Divers have traveled along an underground river 27 miles toward the Las Vegas area before having to turn around.*

Strange men in black suits may not be extraterrestrials, but rather their agents. We're not informed regarding the divers, but as noted later in this chapter, the Navy has frogmen accustomed to such ventures.

Kokoweef Peak, California

In a 1962 issue of The Hidden World, UFO researcher -- the title that's given --Chuck Edwards linked the Kokoweef subterranean drainage network (Chapter 88) to the inventers of flying saucers.

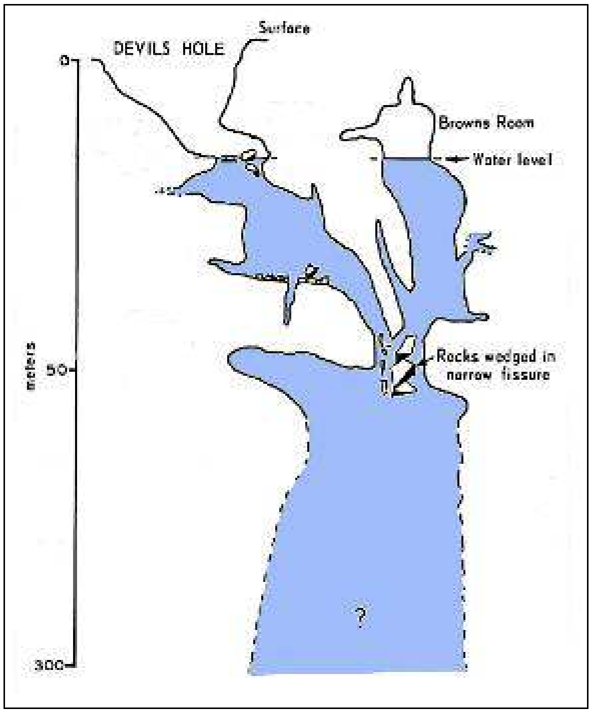
> *Our foundation has located a vast system of underground passages in the Mother Lode country of California. They were first discovered in 1936* [sic. 1936 was the year that Dorr went public with a Los Angeles Times interview.]*, ignored by all even with our best efforts to reveal them. Recently a road crew blasted out an opening verifying our claims. One of the chambers is 200 feet long, 70 feet wide and 50 feet high. We have disclosed what we believe to be a vast subterranean drainage system (probably traversing the Great American Desert country for a distance of more than 600 miles). We believe this system extends out like five fingers of your hand to such landmarks as Zion Canyon in Utah, the Grand Canyon, another runs south from the Carson Sink in Nevada and yet another follows the western slope of the same range, joining its counterpart and ending somewhere in the Mojave Desert.*



> *The legend says that these ancient people landed their ships near or just below large "quays'" or "doors" high up the eastern slope of the Panamints. However after centuries the lake eventually dried up and disappeared, and as a result of this they developed new methods of reaching the world beyond. This, the Paihutes say, was when they began to experiment with the construction of silvery "flying canoes."*

Devils Hole, California

Devils Hole -- no apostrophe, according to the National Park Service -- is a 10 by 20 meter limestone sinkhole in Death Valley National Park flooded to 15 meters from the land surface. The depth to the well's bottom is roughly 120 meters.



Halliday's description of Devil's Hole as rising and falling with the tides, like Dorr's at Kokoweef Peak, suggests a water course connected to an underground ocean.

One might wonder about oceanic tides, however, as a subterranean connection to the Pacific would flood Death Valley. Most, if not all, of the water is derived from the northwest, where it flows at considerable depth under the Nevada Test Site.

As explained by Branton, however, there may be other forces at play. We can refer to Chapter 43, The Hydraulics of Underground Waters, for possibilities.

Legend regarding two divers lost in Devils Hole holds that a SCUBA tank bearing the serial number of one of the divers was found months later in the Bay of Cortez.

Quoting from Branton (1995),

> *According to Sasquatch Researcher* [as with previously cited "UFO researcher Chuck Edwards," we cite titles as given] *Virginia Louis Swanson, Devil's Hole... has been the scene of at least one disappearance. According to Swanson, two boys entered the cave several years ago and were never seen again. Navy scuba divers were lowered on cables and reported seeing a large river which roared up from below, flowing across a wide expanse. They could not estimate its depth because of a myriad of colonnades of black rock through which the river flowed before plunging once again down an abyss. The cave is somewhere near Devil's Hole (which is still open to public view, although "fenced in"), and was allegedly sealed shortly after the disappearance.*

Entry is indeed now restricted, but it's to protect the Devils Hole Pupfish, an endangered species and resident since the Ice Age.

Sumbarines

A submarine would be required to confirm Devils Hole's connection to the Pacific. And according to Branton (1995), this may have indeed occurred.

> *This might confirm the allegations made by one anonymous retired Navy officer that the Navy has knowledge of a vast system or labyrinth of aqua-caverns which meander beneath the surface of California and even into other western states, and that these watery labyrinths exit out into the oceans via huge entrances in the lower walls of the Continental Slope. One of the more extravagant claims is that some of these aqua-caverns are so large that they can be navigated by submarine, and that one nuclear submarine on a secret mapping mission in fact became lost within the maze and was never heard from again.*

The USS Thresher disappeared on April 10, 1963, with a crew of 129 under the command of John W. Harvey, USN. As revelation of nearby alien presence would panic the entirety of Southern California, it comes as no surprise that the official reporting stops at this point.

That's not to say that there's been a lack of unofficial reporting regarding subterranean sub missions, however. We'll quote just one Internet item, from a certain "johnlear."

> *Many years ago a Navy friend of mine told me about a hidden Navy base in Lake Tahoe. He also told me about the "tubes," the Navy underground transportation system. He told me that the techs that worked in the tubes were called "tubemoles."*

In the March 1980 edition of his Rebel Magazine, John J. Williams revealed that many subterranean cavities below the western U.S. have been explored via nuclear submarines to several hundred miles inland, particularly in the region of southern California and the Oregon-California border. According to Williams,

> *Some time ago, I heard a man on a TV interview-show briefly mention that parts of California and neighboring states are floating on the Pacific Ocean! He was a high ranking Naval officer on a top- secret nuclear submarine that has been (and is) exploring and mapping these enormous caverns and passage-ways underneath the West for over 10 years now.*
>
> *A friend of mine finally tracked the man down. He is now living quietly in retirement and asked that no details pointing to him be revealed as he does not want publicity and government attention. After writing this article, I destroyed my files on him.*
>
> *He makes the following statements from his observations:*
>
> 1. *The passageways are labyrinthine with widths from a few to thousands of feet (caverns), averaging roughly about a 100 feet.*
> 2. *Much like dry caverns do, heights and depths vary a great deal and in some cases, two or more caverns or passageways pass over or under each other at different depths.*
> 3. *Most of the entrances lie just off the Continental Shelf*
> 4. *Most of the entrances are too small for submarine investigation; and many that are large enough lie in waters that are too deep.*
> 5. *Some of the caverns (in S. California) are topped with oil while some others are filled with gases believed to approximate our atmosphere (in very ancient times).*
> 6. *The San Joaquin Valley is essentially a portion of the original cavernous area that collapsed eons ago due to its sheer weight.*
> 7. *What is being passed off as the "San Andreas Fault" are large, unsupported chambers that are in the process of collapsing. When the big one finally hits, many scientists in the know believe that most of California will break off like a cold Hershey bar and slide into the ocean!*
> 8. *(Deleted due to the possibility of undue stress and fear which may result from its disclosure.)*
> 9. *A well-known U.S. nuclear submarine lost its way in these passages and disappeared forever.*

Camp Irwin

Leon Davidson, in an early issue of Flying Saucers Magazine, spoke of a network of "underground tunnels in the California desert, at Camp Irwin, near Barstow."

Richard Toronto reprinted an article in his Shaverton newsletter describing a Los Angeles Municipal Water Director who talked with a man who said that he was hired by the government to look for underground water sources for Camp Irwin. The man came across an abandoned mine and near the bottom discovered an earth fault wide enough to traverse until emerging into a river-cavern in which he saw a crystal pure underground river 500 meters wide which flowed out of sight.

The Municipal Water Director claimed to have since discovered at least five similar underground rivers, some die-traced to the Gulf of California and at least one to the Pacific through openings in the continental slope.

While the tale about a fellow who talked with someone who saw something makes no mention of lost civilizations or extraterrestrial, its publication in a UFO newsletter suggests what else may be involved.

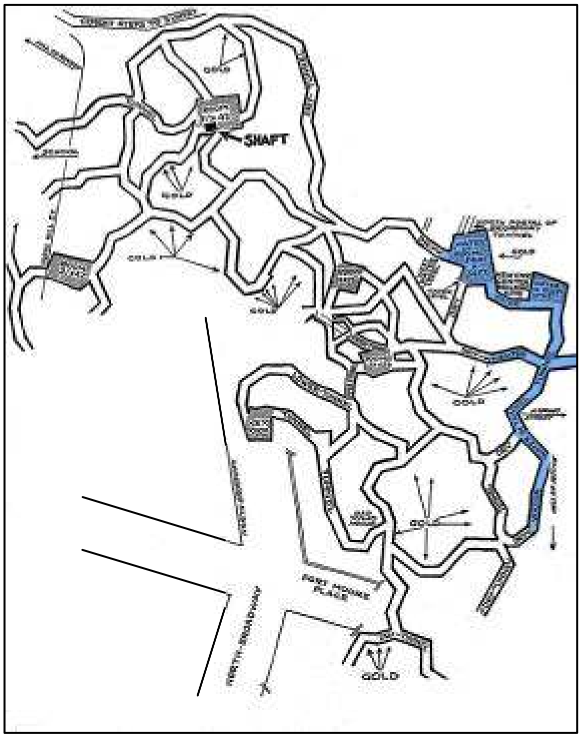
A Municipal Water Director, after all, is a respectable official.

Los Angeles

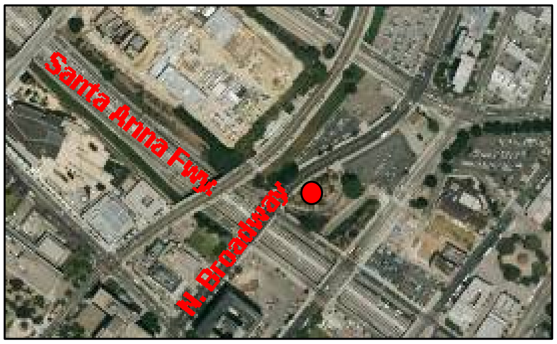
"Lizard People's Catacomb City Hunted," Los Angles Times, January 29, 1934, published a scoop by Jean Bosquet on "Lizard City," a labyrinth deep below Los Angeles chemically excavated by the Lizard People in times long ago. Discovery was achieved by geological mining engineer Warren Shufelt and his radio X-ray apparatus. At time of publication, Shufelt was digging a shaft for verification.

We will concede that the legend of an ancient race of "a much higher type intellectually than modern human beings" seems indeed very likely. Our interest, however, is in the portion of the article pertaining to underground rivers.

> *Engineer Sinks Shaft Under Fort Moore Hill to Find Maze of Tunnels and Priceless Treasures of Legendary Inhabitants.*
>
> *The tide passing daily in and out of the lower tunnel portals and forcing air into the upper tunnels, provided ventilation.*
>
> *Shufelt's radio device consists chiefly of a cylindrical glass case inside which a plummet attached to a copper wire sways continually, pointing, he asserts, towards minerals or tunnels below the surface of the ground.*

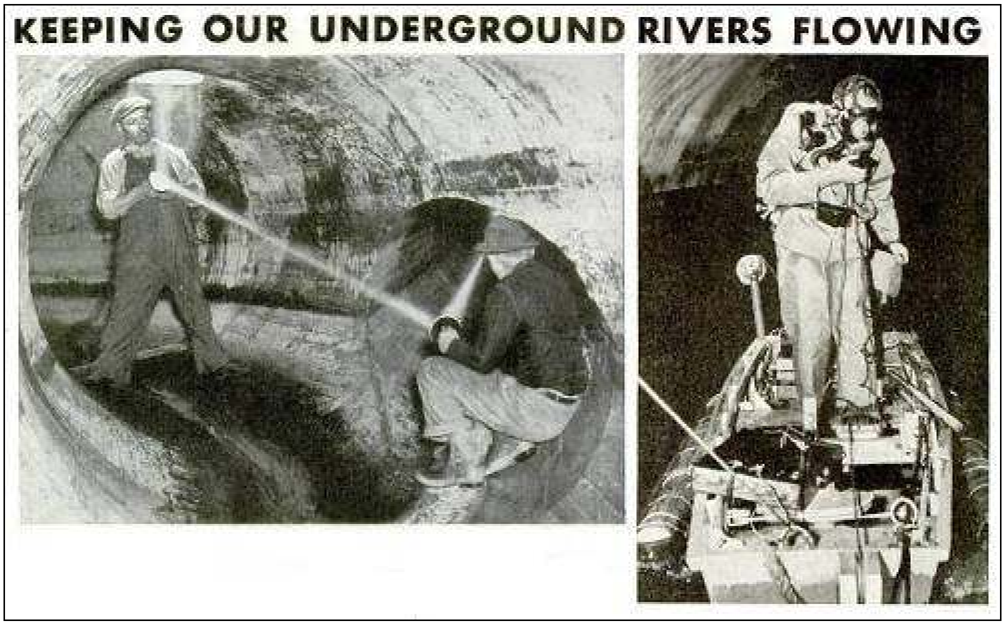


Lizard City layout is shown to the left with tidal tunnels indicated in blue. The site's location in modern Los Angeles is shown below. Santa Monica Freeway construction may have obliterated the entrances to the subterranean site.



The Los Angeles Times article included a photo of Shufelt baling water out of a 70-meter vertical shaft, not an unexpected necessity, as such depth would have taken him to sea level. As he anticipated his objective to be another 250 meters below, however, his tidal air-pump theory would seem to suggest that in Lizard City times, the Pacific itself was itself that much lower than it is today.

And let's look closely at the January 1943 edition of Popular Mechanics.


KEEPING OUR UNDERGROUND RIVERS FLOWING

The caption for the left photo:

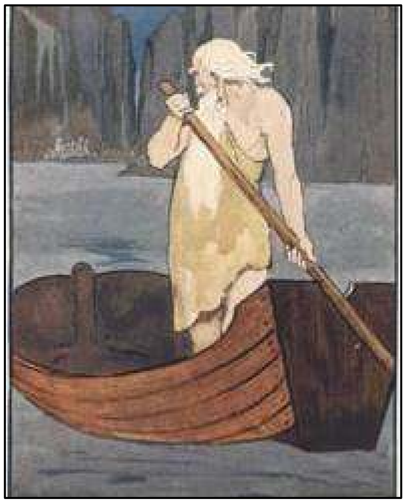
> *Sunlight is made to turn corners with mirrors and safely illuminate hundreds of feet of sewer conduit.*

As we can see the beam, this seems true, laser-like in a pre-laser era. The caption for the right photo, however, seems less likely.

> *Dressed like a man from Mars, an engineer sets forth on a dangerous expedition through 55 miles of Los Angeles sewers.*

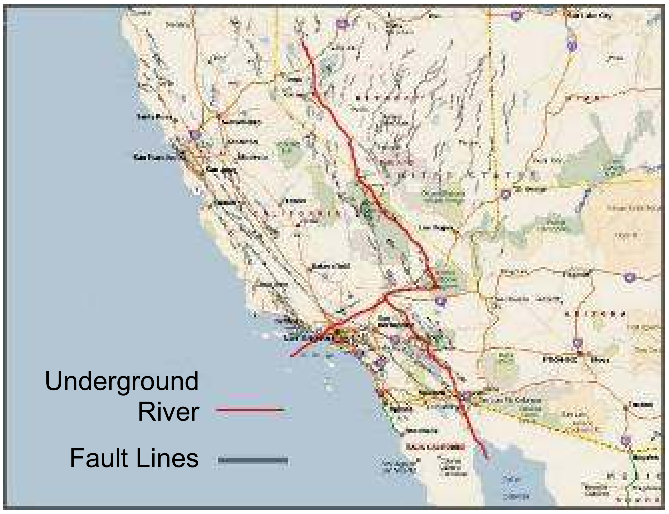
A boatman dressed like a man from Mars in the Los Angeles underground! We suspect otherwise, a Martian photographed in transit to points inland.

Or might it be our Chapter 33 Stygian boatman, in gasmask and sans oar?



The flying saucers, occasional submarine and paddling aliens enter the underworld waterway of the American West under Los Angeles, perhaps near the Santa Monica Pier.

Connecting the Dots

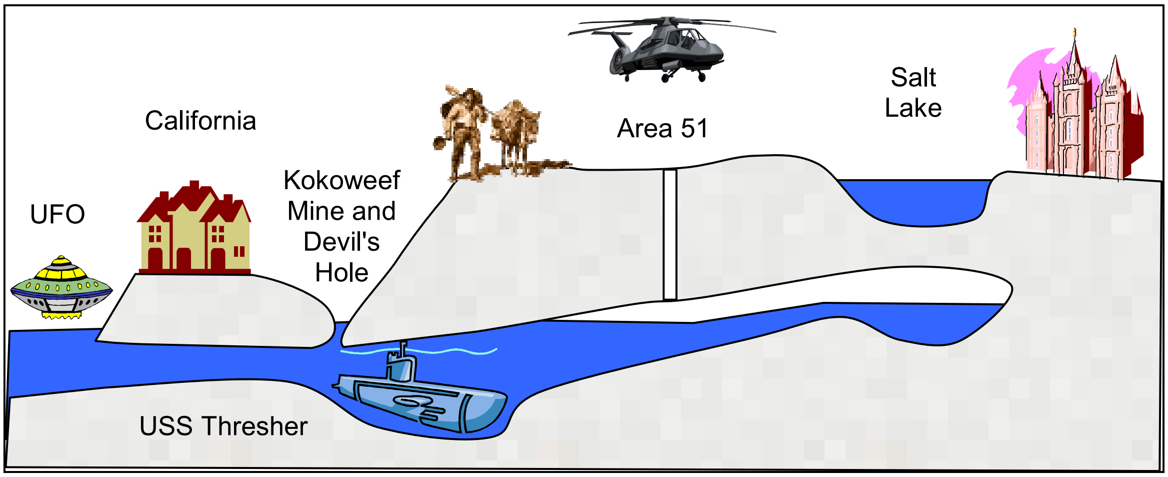

Underground River
Fault Lines

The clues indeed seem to verify the existence of Chapter 86's Rio San Buenaventura!

We're not the first to see connections, of course, as evidenced by the unattributed map published by In-the-Desert.com.

> *This is the approximate location of the underground river. Many accounts of places where the river would start and it's course to the south following earthquake fault lines has led us to this map. Other accounts have the river starting as far north as British Columbia.*

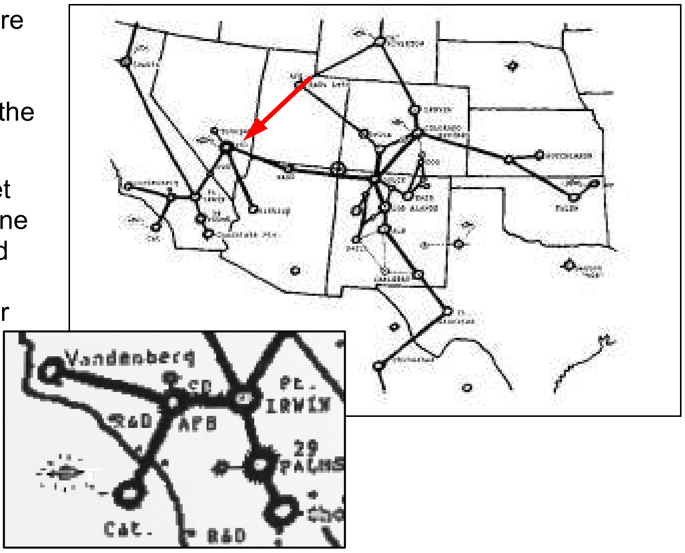
We've noted evidence extending yet further inland, however.


California
UFO
Kokoweef Mine and Devil's Hole
Area 51
Salt Lake
USS Thresher

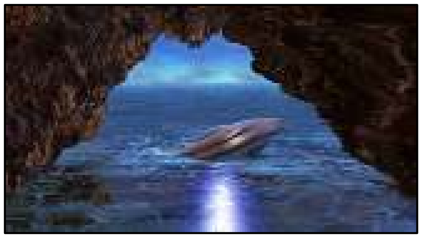
No one claims that all the connections are fluvial, of course, as evidenced by the tunnel map linking secret underground military bases, Nevada's Area 51 being the central command.

It would appear, however, that the secret tunnel map is missing an obvious link, one from Salt Lake to Area 51. Underground rivers meander, but there would be little reason for the main branch to loop as far east as New Mexico.

We've added it in red.


Vandenberg
CP
Ft. IRWIN
R&D
AFB
29 PALMS
Cat.
R&D

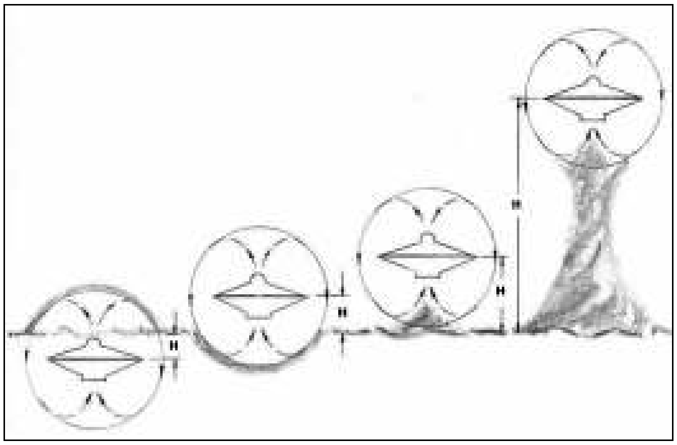
Note the offshore UFO launching facility near Catalina Island. The illustration to the right suggests that the visitors enter the labyrinth on the surface, but secrecy requires that they do it yet submerged.



The photo below appears to be a takeoff, not a launch. As analyzed by Feindt, a takeoff creates an upward vortex.

Underwater Flying Saucers,

The Walkford Files internet posting



Carl Feindt, "Physical Influences of a UFO on Water," internet posting, 2005

A Warning from Below

Raymond Bernard's Hollow Earth (1964) discusses reports from those who've visited the inner world. They speak of a harmonious civilization, people 2.75 meters tall, having no diseases and living hundreds, if not thousands, of years. The Inner Earthers were driven underground by a past thermonuclear war, perhaps the one that sunk Atlantis. Since these beings share our planet, they are understandable concerned about a second nuclear destruction. The atomic bombing Japan led to the increased sightings of UFOs in the 1950s, as the Inner Earth's people were watching. They will not interfere with our lives unless we threaten theirs.

To us, underground rivers are dangerous waterways. To those below, it's the upper world that causes concern.

Conclusion

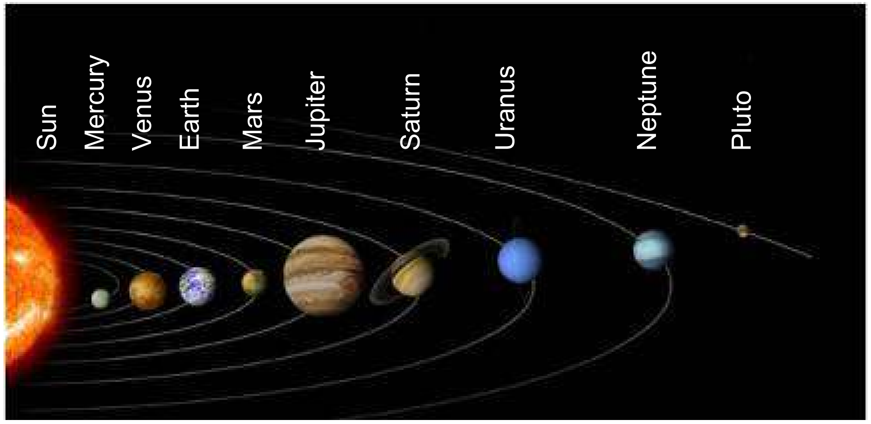
Could an underground network of UFO bases be the fabled Rio San Buenaventura?

We can only speculate, of course, but we can't ignore the general geographical correspendence.

CHAPTER 89

UNDERGROUND RIVERS IN OUTER SPACE

The chapter just completed, Extraterrestrials and Lost Rivers of the American West, looked at alien beings navigating our own underground waterways. Here, we'll look for underground rivers where those visitors perhaps embarked. This chapter should perhaps be called "Underground Rivers Elsewhere in Our Solar System," but we'll use the more-encompassing title in anticipation of more distant discoveries.



We seek planets or their moons where there seems a possibility of a past or present underground river, the last terms loosely interpreted. The "ground" may not be dirt, but an icy crust; the "river" may not flow as do ours.

Given the uniformity tenant of science that fundamental rules don't vary with time or location, if the landscape of a distant planet or moon resembles to some degree a terrain with which we are familiar, what transpires beneath the two may also have similarity.

Thus we seek extraterrestrial likenesses to terrestrial geology associated with subterranean streamflow.

As we look, we'll keep in mind three conditions that must be met for an underground river to exist.

1. There must be a fluid that can also exist in gaseous phase to regain elevation in its cycle. We won't insist it be water, however; it might be a hydrocarbon or something else.
2. There must be an energy source. We sketch the sun in the corner of our own hydrologic cycle diagrams. On objects elsewhere in space, however, power could come from the body's thermal core or from planetary tides, a mechanism we'll describe for the Jovian moon Europa.
3. There must be a mechanism for conduit development. On the earth, we've two possibilities: karstification and lava tubing. The chemistry on another body in space may not be right for carbonate karst, per se, but there might be a like-acting process involving dissolution or corrosion. Absent the dispersal of solutes or dissociated particulates from the solid-liquid boundary, a stagnant pool will insulate itself and at we'll have but a motionless subsurface sea.

A planet or moon may have once had an environment different from that of the present. Atmospheres can alter or even disappear. Cores can cool. Volcanoes have their season. We need to look at each planet or moon both as it now and how it might have once been.

In our underground rivers odyssey, we'll look for bodies in space having signs of any sort of hydrologic activity. Liquid on the surface might point to flows below.

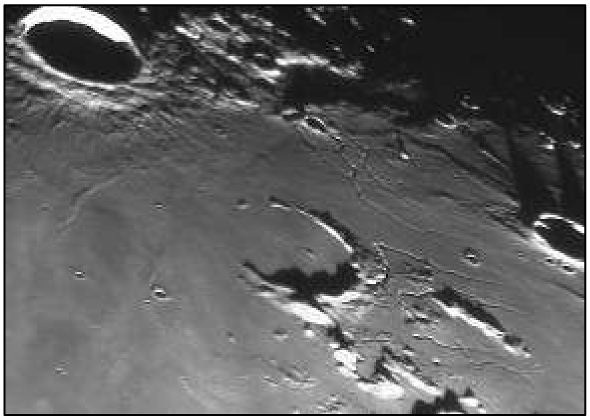
☽ The Moon

We'll begin with the celestial body about which we know most, our moon. There, we'll prospect for sublunarian rivers -- the adjective coined, but it has to be correct -- from three perspectives: fiction, pseudoscience and actual science.

Lunar maria are formations on the moon's surface that when viewed by eye from the earth, seem to resemble seas. Galileo, however, was skeptical regarding the interpretation. From his Dialogue Concerning the Two Chief World Systems (1632),

> *What is clearly seen in the moon is that the darker parts are all plains, with few rocks and ridges in them, though there are some. The brighter remainder is all fill of rocks, mountains, round ridges, and other shapes, and in particular there are great ranges of mountains around the spots.*
>
> *I think that the material of the lunar globe is not land and water, and this alone is enough to prevent generations and alterations similar to ours.*

Galileo was correct. Lunar mares are not ocean beds, but basaltic plains.

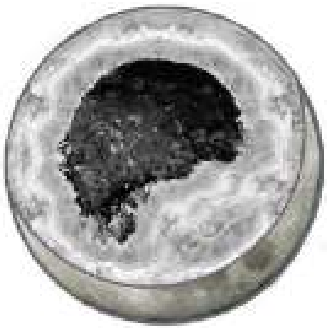


That's not to say, however, that liquid once flowing on lunar rock hasn't left its mark.

The photograph to the right taken from Ludiver Observatory shows meandering and branching channel beds, the agent haven been not water, but lava.

But who's to say there couldn't be a very different sort of geological history within? This sort of question is precisely why we have fiction, both of the literary variety and of the esoteric scientific sort.

If the fiction and pseudoscience of extraterrestrial underground waters seem closely akin treatments afforded by the same writers to their terrestrial equivalents, it's because writers of fiction and conceivers of alternative science have unabashedly rehashed tales and theories they've constructed for the earth.



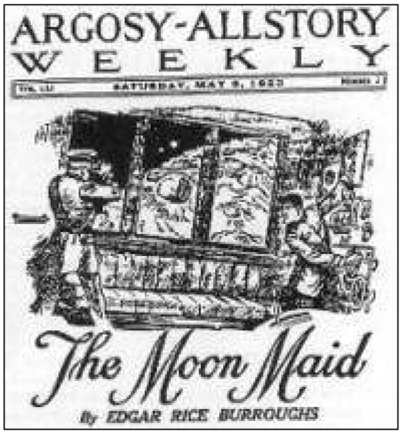
Akin to the hollow earth in Chapter 14, how about a hollow moon?

In The First Men in the Moon (1901), H.G. Wells describes the insectide "Selenites" dwelling inside such a satellite.

A hollow moon "Sulva" is background for That Hideous Strength (1945) by C.S. Lewis.

The Lomokome Papers (1947), Herman Wouk's venture into science fiction, employs a like setting.

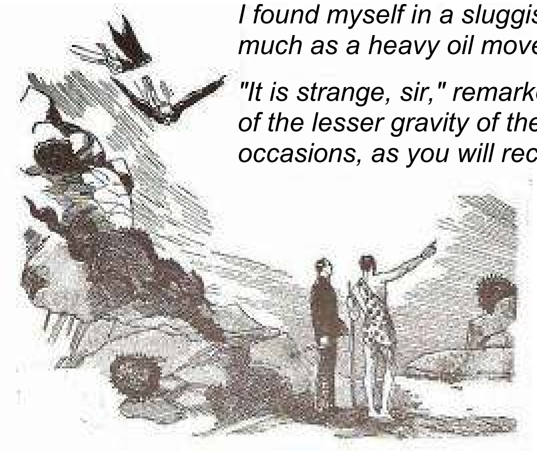
We'll only delve into one such volume, however, as one's enough -- The Moon Maid (1922) by Edgar Rice Burroughs whom we met in Chapter 20, More Boys Club Series.



Arriving at the moon,

> *During the next ten miles our speed diminished ran idly, until we suddenly realized that we were no longer falling, but that our motion had been reversed and we were rising. Up we went for approximately eight miles when suddenly we began to fall again. Again we fell, but this time for only six miles, when our motion was reversed and we rose again a distance of about four miles. This see-sawing was continued until we finally came to rest at about what we estimated was a distance of some one hundred and thirty miles below the summit of the crater. It was quite dark, and we had only our instruments to tell us of what was happening to the ship, the interior of which was, of course, brilliantly illuminated and comfortably warm.*
>
> *Now below us, and now above us, for the ship had rolled completely over each time we had passed the point at which we came finally to rest, we had noted the luminosity that Norton had first observed from above the mouth of the crater. Each of us had been doing considerable thinking, and at last young Norton could contain himself no longer.*
>
> *"I beg your pardon, sir," he said deferentially, "but won't you tell us what you think of it; what your theory is as to where we are and why we hang here in mid-air, and why the ship rolled over every time we passed this point?"*
>
> *"I can only account for it," I replied, "upon a single, rather preposterous hypothesis, which is that the Union is a hollow sphere, with a solid crust some two hundred and fifty miles in thickness. Gravity is preventing us from rising above the point where we now are, while centrifugal force keeps us from falling."*

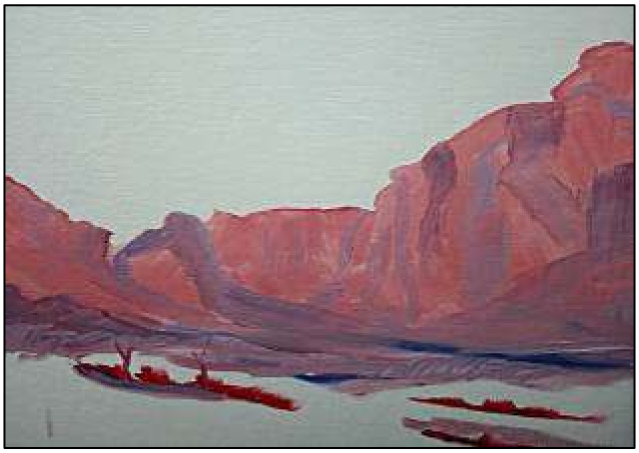
The hollow-moon geophysics is the hollow- earth geophysics of Chapter 14. Regarding the inner waters,



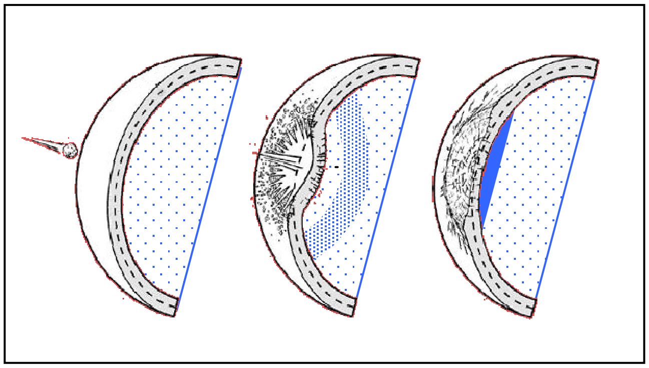
> *I found myself in a sluggish, yet powerful current, the water seeming to move much as a heavy oil moves to the gravity of Earth.*
>
> *"It is strange, sir," remarked Jay, "that none of us thought of the natural effects of the lesser gravity of the Moon. We have discussed the matter upon many occasions, as you will recall, yet when we faced the actual condition we gave it no consideration whatsoever."*
>
> *The only important entry upon the log since I had turned in was West's report of the results of his analysis of the water, which showed that it was not only perfectly safe for drinking purposes but usually pure, with an extremely low saline content.*
>
> *I stepped into the river, and as I did so I glanced to my left to see stretching before me as far as my eye could reach a vast expanse of water. Here then I had stumbled upon the mouth of the river and, beyond, a lunar sea.*
>
> *We crossed many rivers, for the lunar world is well watered. We skirted several lakes, and at one point of high ground, I saw, far at our left, the waters of what appeared to be a great ocean.*
>
> *Rushing down from the hillside, the water poured in torrents into the ravine, and presently, though it must have been twenty or thirty feet deep, it was filled almost to overflowing. Whoever had sought refuge there would have been drowned and washed away to the big ocean far below.*
>
> *Moh-goh was already up and in the bath, a marble affair fed by a continuous supply of icy water which originated among the ice-clad peaks of the higher mountains behind Laythe.*

Again, it's very much the same type of prose devoted to imaginary explorers discovering the waters of a hollow earth.

"The Moon Maid" (2007) by William Cane interprets the interior of the hollow moon based on the novel.



A pseudo-scientific rationale for the hollow moon is the impressively-titled "accretion-disk dynamics." Others subscribe to the Vasin-Shcherbakov Theory that the moon is an alien spacecraft.



According to believers, evidence for hollowness can be seen with a telescope. The craters wouldn't be so large, but for the thin shell's rebound from meteorite impact.

We've also speculated how vapor within the hollow globe could be condensed by shock wave compression, the condensate then forming a sea.

We needn't penetrate a hollow-moon, however, to find water under the lunar surface.

Water was entrapped in Apollo 17 rock samples. From the July 8, 2011 edition of Science, by Erik H. Hauri, Thomas Weinreich, Alberto E. Saal, Malcolm C. Rutherford, and James A. Van Orman,

> *Primitive magmatic melt inclusions from the moon contain as much water as some terrestrial mid-ocean* ridge magmas
>
> *The moon has long been thought to be highly depleted in volatiles such as water, and indeed published direct measurements of water in lunar volcanic glasses have never exceeded 50 parts per million (ppm).*
>
> *Here, we report in situ measurements of water in lunar melt inclusions; these samples of primitive lunar magma, by virtue of being trapped within olivine crystals before volcanic eruption, did not experience post-eruptive degassing. The lunar melt inclusions contain 615 to 1410 ppm water and high correlated amounts of fluorine (50 to 78 ppm), sulfur (612 to 877 ppm), and chlorine (1.5 to 3.0 ppm). These volatile contents are very similar to primitive terrestrial mid-ocean ridge basalts and indicate that some parts of the lunar interior contain as much water as Earth's upper mantle.*

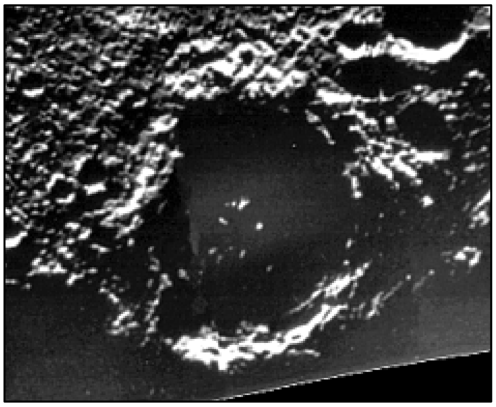
As reported in "Evidence of Water Beneath Moon's Stony Face," New York Times, May 27, 2011,

> *Now, scientists analyzing tiny fragments of hardened lava from long-ago lunar eruptions report that the fragments contain about as much water as similar magmas on Earth, meaning there is plenty of water inside the Moon too.*

"There is a reservoir down there in the Moon that has the same concentration of water as some reservoirs in the upper mantle of Earth," Dr. Saal told the Times. "That's for sure."

No one at NASA is proposing that such water has gathered into waterbodies, but what's established is that there's water.

☿ Mercury



Mercury's silicate surface is similar in appearance to that of our moon, an ancient surface heavily cratered and without evidence of plate tectonics. Mercury has a wispy atmosphere of atoms blasted off its rock by solar wind, but because the planet is so hot, these atoms quickly escape into space. Mercury has features akin to the maria on our own moon, but nobody has thought to call them "seas." Surprisingly, however, NASA Deep Space Network radar observations of Mercury's north pole (shown to the right) seem to reflect water ice in the protected shadows of craters.

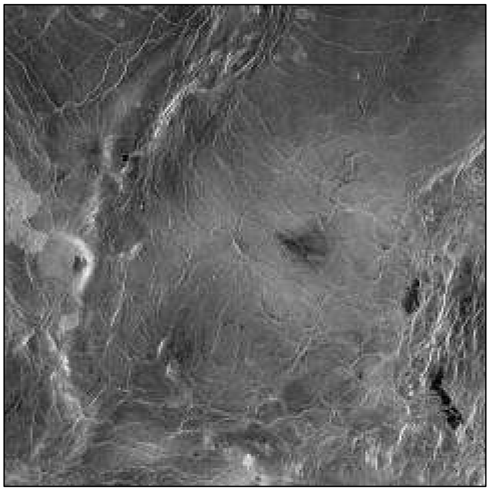
The Roman deity Mercury was known to the Greeks as Hermes, guide to the underworld. Despite the radar observations, there's a snowball's chance in Hermes' territory for underground rivers on Mercury.

♀ Venus

According to astrobiologist David Grinspoon in Venus Revealed: A New Look Below the Clouds of Our Mysterious Twin Planet (1998),

> *The vast volcanic plains that cover nearly all low-lying areas are the long-sought global "oceans" on the surface of Venus–frozen oceans of basalt. One of the most astounding surface forms discovered by Magellan furthers the analogy: this ocean is fed by rivers! We see numerous thin, meandering channels, typically a mile wide and thousands of miles in length. The longest of these, Baltis Vallis, winds more than forty-two hundred miles over the plains. Baltis is longer than the Nile and thus can safely be called the longest river anywhere within several light-years of here. On Earth or Mars we would interpret such features as evidence of past or present running water. The analogy with structures carved by terrestrial water goes quite deep. We see fanlike river deltas, meanders, and bars, and places where streams have flooded their banks.*

Skeptics find the analogy strained. "Tributaries" that slope the wrong way show little evidence of damage from ground movement causing the reverse in gradient. There's no progressive widening of the main channel. The "channels" are more likely overlapped lava flows intercepted by fractures and folded rises.



A 1996 Magellan photo.

Today's environment is much too hot for liquid water but there does appear to be a small amount of water vapor amidst the carbon dioxide atmosphere acidified by sulfur gases. Lakes of sulfuric acid have been hypothesized, but sulfuric acid raindrops would evaporate in transit.

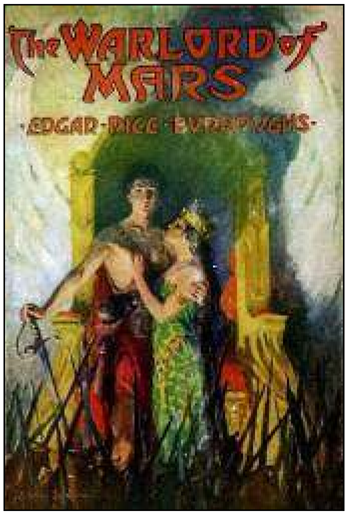
Infrared spectrometry suggests that Venus might have had water oceans at one time, but given that the surface has been reworked by intensive igneous activity, the hypothesis is hard to test.

With an atmospheric pathway, we're at least step closer to the possibility of a circulatory system than we were on our own moon.

♂ Mars

We cited Marshall Gardner's A Journey to the Earth's Interior (1913) in Chapter 14, Hollow Earth Geophysics, but the author also presents a vacant case -- interpret this as you like -- for Mars based on a gleam of light seen emanating from the planet's north polar area. As a hollow earth and hollow moon more than satisfy our curiosity regarding hollow bodies in space, however, we'll not further utilize Gardner in our quest for underground rivers.

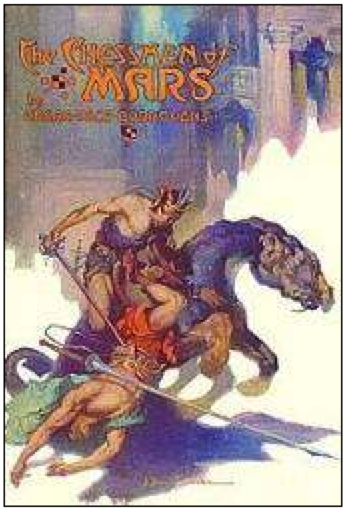
For fictional underground rivers on the Red Planet, we turn once again to Edgar Rice Burroughs.



The Warlord of Mars (1914)

At last the truth dawned upon me -- I was following a subterranean river which emptied into the Iss at the very point where I had hidden.

The rowers were now quite close to me. The noise of their own paddles drowned the sound of mine, but in another instant the growing light ahead would reveal me to them.

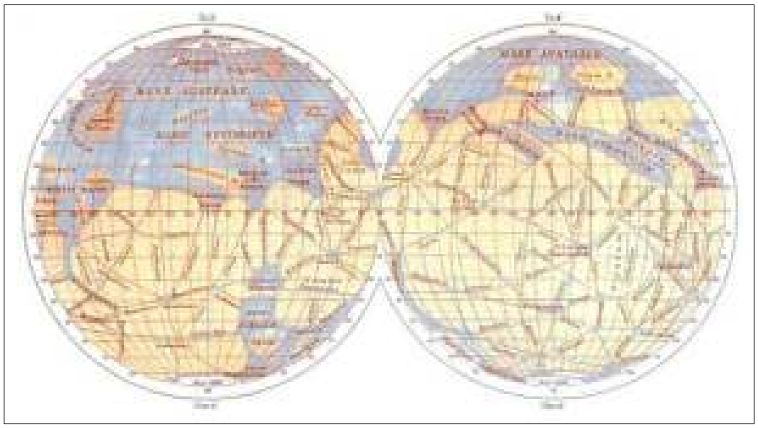


The Chessmen of Mars (1922)

Tons upon tons of dirt must have been removed, and for a long time he wondered where it had been deposited, until in following downward a tunnel of great size and length he sensed before him the thunderous rush of subterranean waters, and presently came to the bank of a great, underground river, tumbling onward, no doubt, the length of a world to the buried sea of Omean.

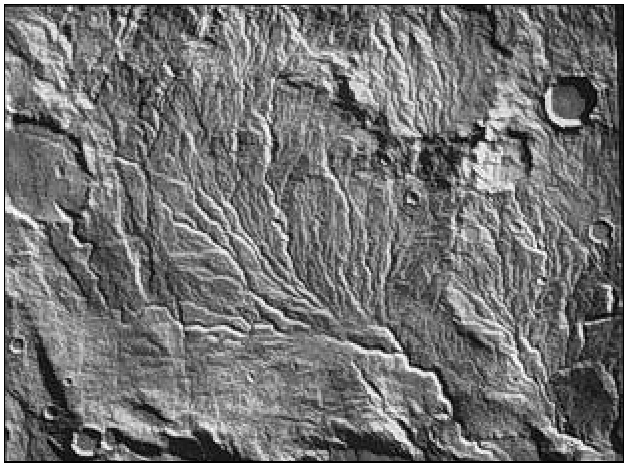
Burroughs rolled out such verbiage for Earth, Moon, Pellucidar or Mars. Boys Clubs like adventure wherever it occurs.

Scientists have likewise hypothesized Martian waters, and telescopic observations from the time of Galileo gave credibility to what appeared to be canals. Giovanni Schiaparelli's 1877 canal map is to the right.



Modern astronomy has revealed the canals to be an optical illusion, but like the seas of our own moon, popular lore lingers.

Like Venus, liquid water may have once covered some of the planet's surface, but Mars retains better evidence in what appears to be ancient shores of a primordial Oceanus Borealis and traces of catastrophic floods.



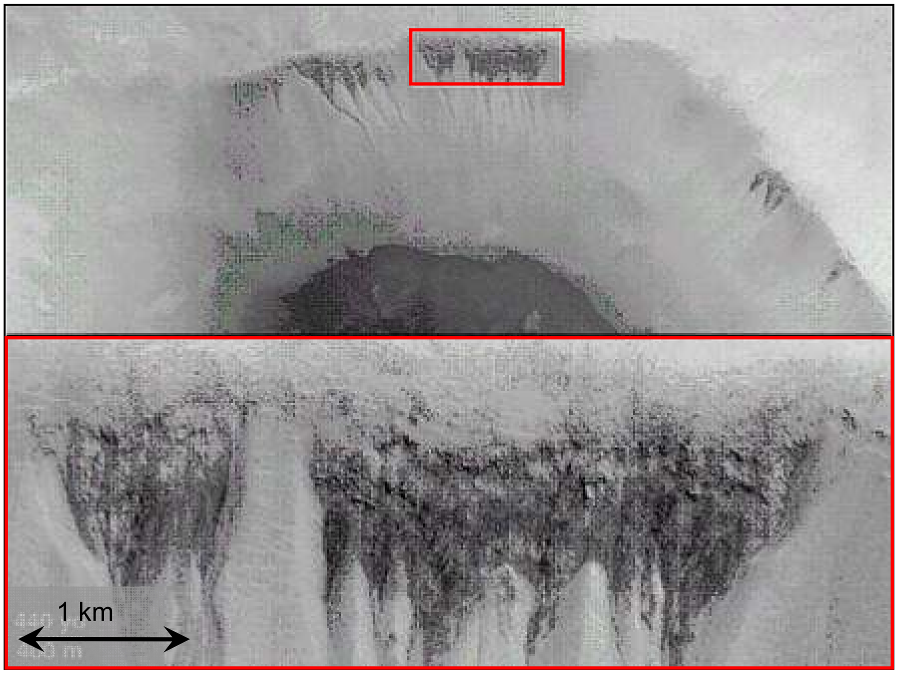
Signs of past drainage.

Artist's conception

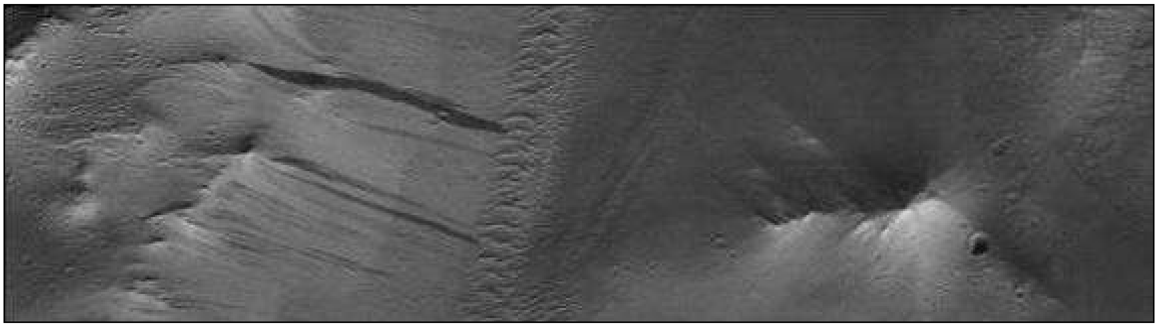
And not all the signs of water are ancient and -- particular to our interests -- are on the surface.

Photographic evidence of subsurface piping beneath a crater rim is shown to the right.

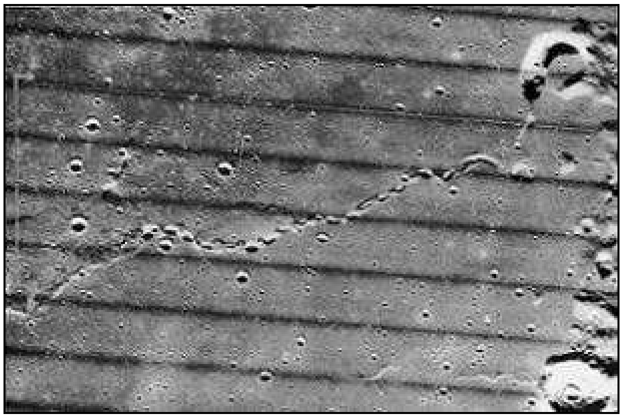
The flow features are meters wide on 25 to 40-degree slopes. Repeat imaging by HiRISE, a University of Arizona project, indicates that the features grow during warm seasons and fade in cold seasons.

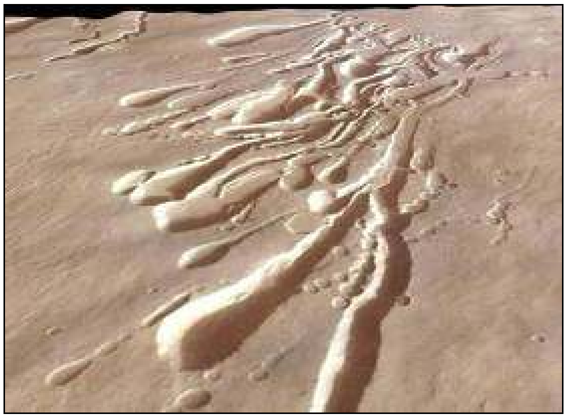


The image below shows downstream erosion from what might be geologically-recent subsurface drainage from crater and valley slopes.



Lava tubes are evidenced by chain of collapsed conduits, below, left. On the right is a closer view of uncollapsed tubes on the surface.



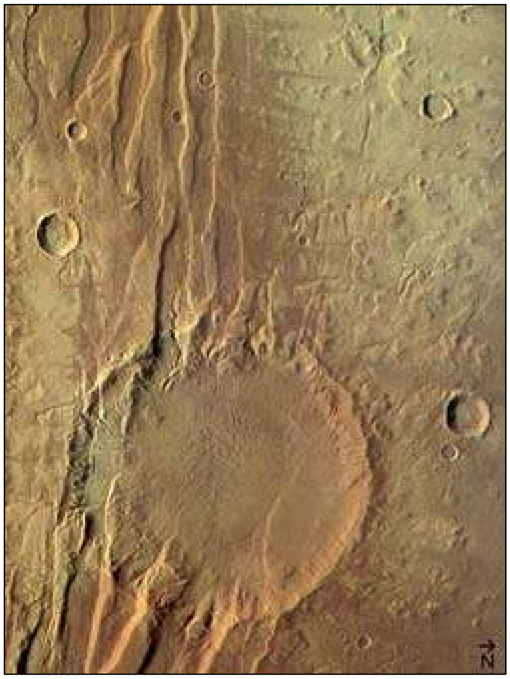


Images sent by NASA's Mars Express of the landscape surrounding the giant volcano Ascraeus Mons reveal sinuous channels, 1-2 kilometers wide and 20-50 kilometers in length, which appear to have been caused by expelled boiling fluids. At the low atmospheric pressure, a volatile liquid boils quickly as it erupts from the sides of a volcano, surging with force capable of carving channels down the slope and creating gigantic debris flows.

According to John Murray, et al. in "Late-stage water eruptions from Ascraeus Mons Volcano, Mars: Implications for its Structure and History," Earth and Planetary Science Letters, July 25, 2009, some of the channels may have been carved by water flowing underground, later to be exposed when the roof of the conduit collapsed.

"If we had water flowing below the surface, we have a warm and wet environment, protected from cosmic radiation. This is a great place for life to develop,' suggests the lead author.

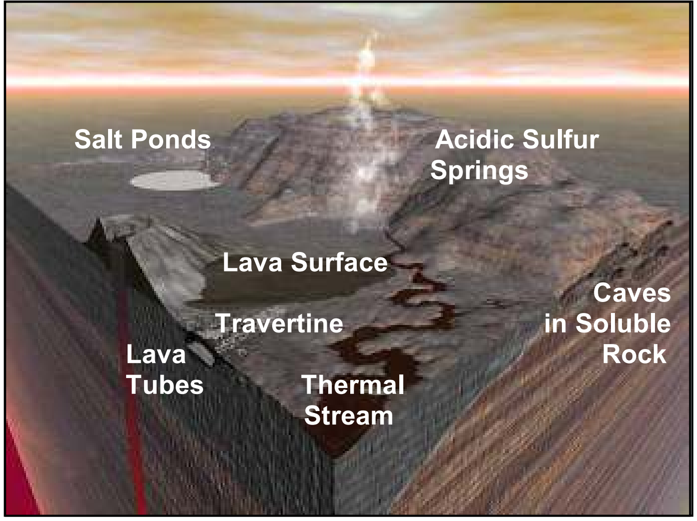
The image to the right is of Mars' Acheron Fossae region taken by Mars Express high-resolution stereographic photography. The region's mythological name, of course, suggests an underground river, but we'll focus on the large crater, 55 kilometers in diameter and 2 kilometers, rim to floor. Eroded material carried from outside the crater has resurfaced its floor, compelling evidence for an epoch of runoff.



Mars might even be a candidate for karstification, as its rock contains calcium carbonate and its atmosphere contains carbon dioxide, but even with the chemistry in order, there's not a sufficient hydrologic cycle pumping acidified precipitation through the rock. This isn't to say, however, that there couldn't have once been a wetter time when solution might have occurred.

The artistic rendition to the right portrays a fairly earth-like Martian hydrogeology. Groundwater isn't shown, but to complete the cycle, water presumably seeps from the ponds and streams, is reheated below and rises to the vents.

Travertine is a form of limestone deposited by mineral springs, and thus the "Caves in Soluble Rocks" to the right.



We'll cite "Mars Tubes," a 2005 National UFO Center web posting, for its mention of lava tubes, but revelations from the august-sounding National UFO Center should perhaps have been in the chapter before, the one about Extraterrestrials.

> *It is likely the entire planet is crisscrossed with lava tubes. Many seemed to be formed along valleys and natural low lying former river or creek beds. Once the volcanic tube is laid down water eventually flows through the tubes.*

Lava tubes could be of value for space exploration, according to "Identifying Lava Tubes and Their Products on Olympus Mons, Mars and Implications for Planetary Exploration,".42nd Lunar and Planetary Science Conference, The Woodlands, Texas, 2011, by J.E. Bleacher, et al.,

> *Developing a series of criteria for identifying lava tubes on other planets is critical for the planetary community as these features are discussed as possible protected habitation zones for native life and future human explorers.*

The possibility of "protected habitation zones for native life" catches our attention. Life of any sort requires water, and where there's a damp tube, there could just a well be a passage with standing or flowing water.

The Red Planet may lack canals, but we've visual indication of fluvial erosion, subsurface emergence and lava tubes. Underground rivers seem unlikely today, but enough of the hydrologic pieces fit together to make a plausible case that there once might have been such.

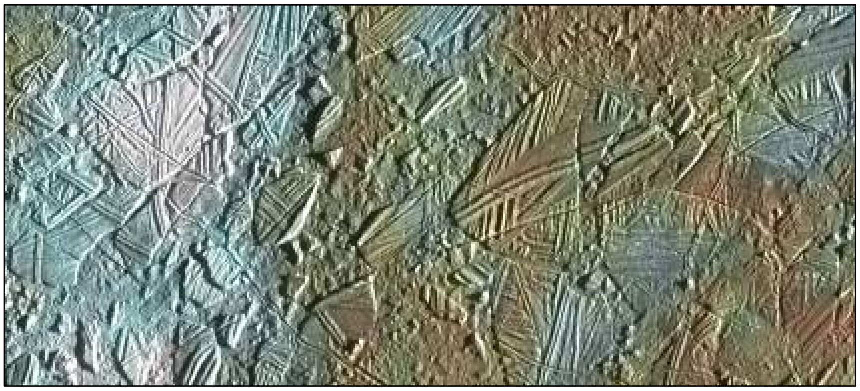
♃ Jupiter

Because of its earthlike temperature and pressure, Jupiter possesses an atmosphere in which water droplets may condense. Water ice seems to be a significant component of the Jovian core, but on the whole, Jupiter consists of trapped helium, hydrogen and water vapor.

We may do a bit better with its moons, however. Of the planet's largest, Io, Europa, Ganymede, and Callisto, all but the first are believed to have iced-over oceans. We'll confine our discussion to Europa, as that the one we've most successfully passed spacecraft by.

Europa has a core; a rock envelope around it; a thick layer of water or slushy ice and impure water ice on the surface. Europa is thought to have twice as much water as does Earth, a surprise to most of us.

Jupiter's immense gravity causes tides sufficient to fracture the icy crust. Images taken by the Galileo spacecraft show fractured ice and where expressed liquid may have frozen on the surface.

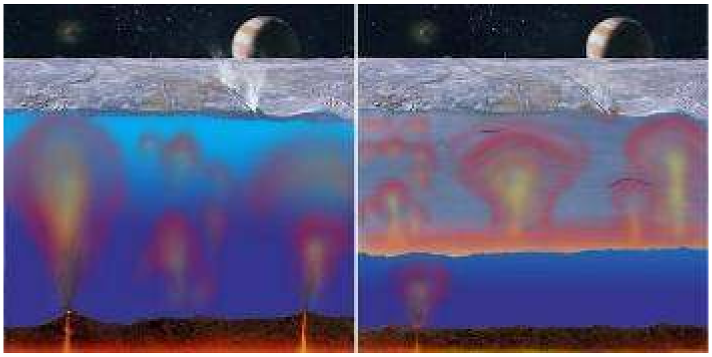


The fragmented chunks of ice are similar in appearance to those in our own polar seas during a springtime thaw. The sparsity of craters suggests that the subsurface ocean wipes the record clean with regularity.

From "Galileo Findings Boost Idea of Other-Worldly Ocean" from NASA's Jet Propulsion Laboratory, NASA, January 10, 2000,

> *When NASA's Galileo spacecraft swooped past Jupiter's moon Europa a week ago, it picked up powerful new evidence that a liquid ocean lies beneath Europa's icy crust.*
>
> *"I think these findings tell us that there is indeed a layer of liquid water beneath Europa's surface," said Dr. Margaret Kivelson, principal investigator.... "This new evidence certainly makes the argument for the presence of an ocean far more persuasive."*
>
> *It appears that the ocean lies beneath the surface somewhere in the outer 100 kilometers, the approximate thickness of the ice/water layer.*
>
> *These latest findings are consistent with previous Galileo images and data showing a tortured surface seemingly formed when Europa's surface ice broke and rearranged itself while floating on a sea below.*

Observation of spherical flexure and measurement of magnetic variations help estimate the ice thickness, but ice-penetrating radar will solve the question, just as it's done beneath Antarctica.



A NASA/JPL artists' conception illustrates Europa's thick-ocean/thin-ocean alternatives.

"We've learned a lot about Europa in the past few years," Prof. William McKinnon of Washington University told Science Daily, December 14, 2007. "Now the scientific community has come to a consensus that there most certainly is an ocean. We're ready to take the next step and explore that ocean and the ice shell that overlays it."

An underground river? No, more like an under-ice ocean. But as we'll see with Saturn's moon Enceladus, we can't be sure it's all ice on top.

♄ Saturn

Like Jupiter, Saturn likely has water ice as a significant component of its core, but may not have much else that's solid. Again the moons may be better candidates for geological processes. We'll look at two, Enceladus and Titan.

Along with Earth, Mars and Jupiter's Europa, Saturn's moon Enceladus is one of the places in the Solar System for which there is direct evidence of water. Cyrovolcanic mountains ("ice volcanoes" in which erupting volatiles condense to solid form when vented to the low temperature) indicate that the moon has ample water within, heated geothermally, or like Jupiter's Europa, by tidal action.

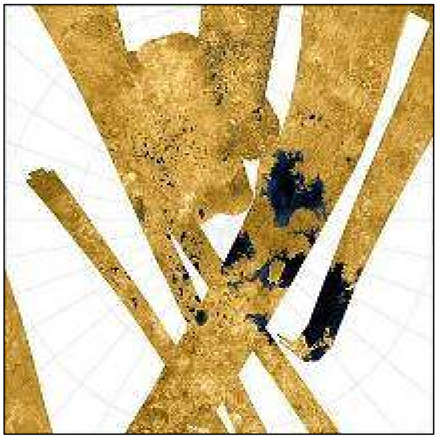
Spacecraft flyby revealed cyrogeysers ("ice geysers," less voluminous than cyrovolcanoes) shooting plumes consisting of about equal parts ice and water vapor hundreds of kilometers into the sky. As discussed in Chapter 45, Subterranean Geophysics, where there's a geyser, there's a conduit directing it to the surface. There's evidence for an ocean at a few hundred meters to a few kilometers beneath the moon's icy shell.

Rather than an explosive emission caused by expanding bubbles rising directly from a hidden ocean, intermediate caverns of vapor may moderate the flow.

The atmospheric composition of Saturn's moon Titan resembles that of an early earth, the major difference being Titan's -178° C temperature.

Scientists believe that methane- and ethane-laden rain on Titan carve meandering channels to lakes and seas trapped in volcanic depressions. As explained by Alex Hayes of California Institute of Technology in Science Daily, October 12, 2007,

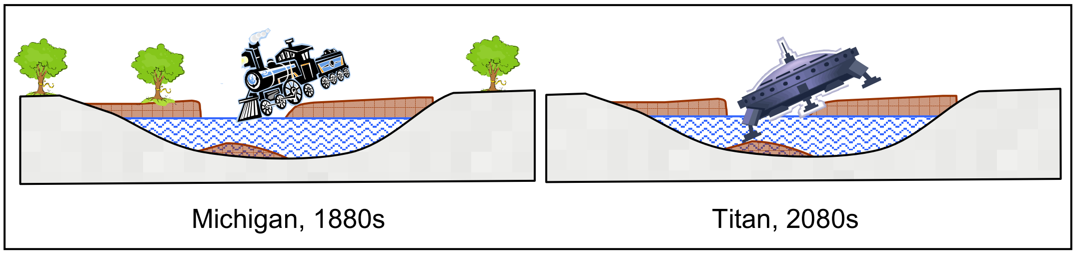
> *The lakes we are observing on Titan appear to be in varying states of fullness, suggesting their involvement in a complex hydrologic system akin to Earth's water cycle.*
>
> *The lakes we have seen so far vary in size from the smallest observable, approximately 1 square kilometers, to greater than 100 000 square kilometers, which is slightly larger than the great lakes in Midwestern USA. Of the roughly 400 observed lakes, 70 percent of their area is taken up by large "seas" greater than 26 000 square kilometers.*



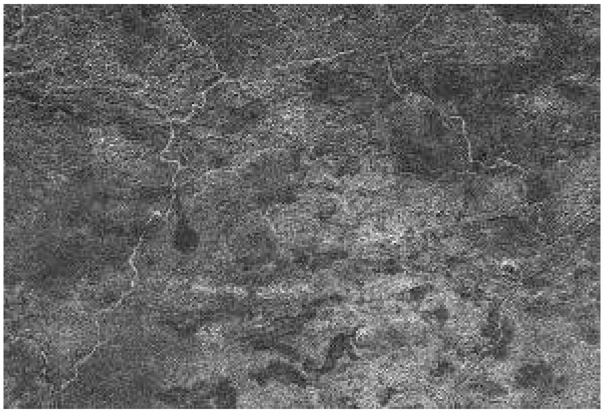
About 14 percent of the false-color mosaic of Titan's north polar region is covered by what seems to be hydrocarbon lakes. Features appearing darkest are thought to be liquid; solid surfaces appear as brown.

Titan's surface was thought to be an icy crust until the flyby, the mostly-solid surface a surprise to investigators. Significant to our interest in underground waterbodies elsewhere in the Solar System is the possibility that oceans we presume to be topped with ice crusts could also lie under visible "ground."

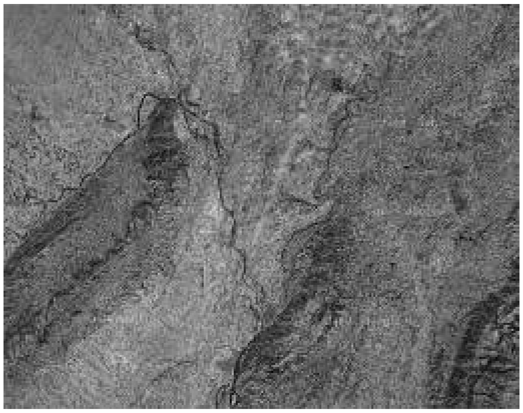
We hesitate to offer advice to rocket scientists, but we'll point out what we discovered in Chapter 74. In the same manner that incrusted lakes can fool railroad men, incrusted seas can fool flyby photographers.



Xanadu, an Australia-sized region on Titan, has meandering channel beds similar those of Chengdu, China, the Xanadu of Kubla Khan, Chapter 30, Down to a Sunless Sea.



Xanadu, Titan



Chengdu, China

The Chinese terrain lies within the South China karst region (Chapter 53), but we can't presume the same geochemistry on Titan where the carving force may have been streams of methane or ethane. Titan's drainage networks might have once flowed onto areas now covered by dunes, what's referred to as Titan's "sand seas," or even to still-visible hydrocarbon lakes at the satellite's poles.

Radio wave reflection suggests a liquid ocean with a 10-or-more percent ammonia content acting as antifreeze some 50 kilometers down.

♅ Uranus and ♆ Neptune

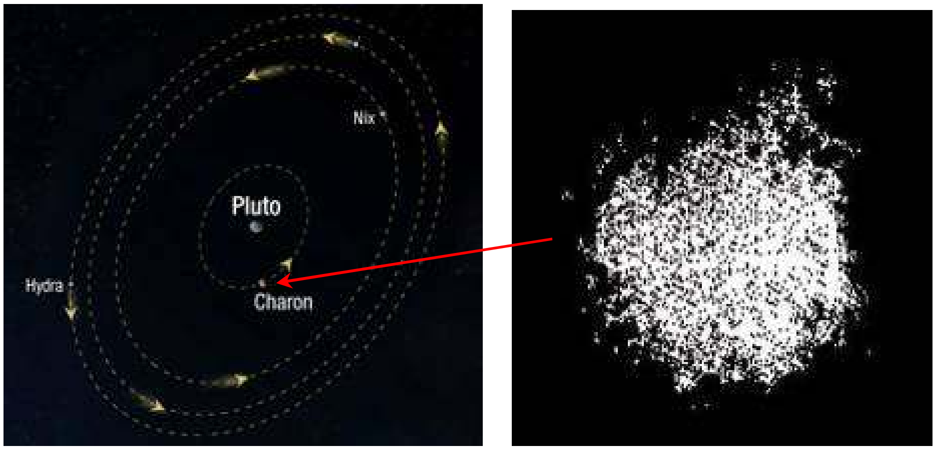
Uranus and Neptune are thought to have cores of iron and silicates surrounded by a mantel of water, methane and ammonia ices, similar to the composition of Saturn's Titan. Unlike the polar seas of the latter, however, the oceans of Uranus and Neptune -- if there are such -- would be compressed by the thick atmospheres. Neptune has an internal heat source; Uranus does not.

We'll not find underground rivers in these places because there's no ground.

♇ Pluto

Pluto's moon Charon is just over half the size of Pluto. Mutual eclipses of Pluto and Charon allow spectrography of the planet alone and then the pair; the difference reveals the composition of Charon's surface. Whereas Pluto is covered with nitrogen and methane ices, Charon's appears to be plated by less volatile water ice, probably deposited by cyrogeysers active in the geological sense, as solar radiation would have degraded older ice to an amorphous state in only 30,000 years, an astronomical heartbeat.

Charon's very name, of course, demands the presence of an underground river, but the ice is all the evidence currently available.



Looking for Solar System-wide commonalities, the possibility of a Plutonain sea falls within speculation regarding ice-covered seas on the moons of other planets.

Smaller icy bodies where the liquid layer beneath the icy crust may be in direct contact with underlying rock, allowing dissolution of minerals and salts	Larger icy bodies where high-pressure ice may underlie the liquid layer
Pluto Rhea, Saturn Titania, Uranus Oberon, Uranus Triton, Neptune	Ganymede, Jupiter Callisto, Jupiter Titan, Saturn

Conclusions

Lunar and Martian underground rivers in science fiction are much like underground rivers of corresponding terrestrial fiction; they're settings for stories about plot. Actual science, however, tells a richer story.

On our moon we've found water, but nothing that merits being called a river.

> On Saturn's moon Xanadu, however, there are signs of what seems to have once been rivers. Landforms on several seemingly-desiccated Solar System bodies suggest past epochs when fluids flowed freely.
>
> Mars seems to have ice springs and lava tubes that might convey subterranean water. The planet may even today have a rudimentary hydrologic cycle.
>
> We've remotely sensed liquid seas buried beneath the frozen surfaces of other extraterrestrial bodies.

We began this chapter by listing three necessary conditions for underground rivers to exist elsewhere in the Solar System. Between planets and moons, we seem to have met them all. Whether the conditions are (or once were) mutually satisfied at any location is yet to be determined, but there is indeed the possibility of underground rivers in outer space.

CHAPTER 90

WHY DO WE BELIEVE WHAT WE BELIEVE?

Or, to put the question in terms of underground rivers, why do we think that subterranean streams flow beneath us when we are reasonably well informed that what's flowing down there is mostly through mud and fractured rock?

We will divide the question of belief into two parts, "As Children" and "As Adults," though we may find the psychological bases to be not that different. In each, we will mention a few reasons suggested by experts and add a few examples of how beliefs become reinforced.

As Children

Jean Piaget noted in The Language and Thought of the Child (1959) that,

> *There is in the child a tendency towards justification at all costs, a spontaneous belief that everything is connected with everything else and that everything can be explained by everything else.*

To test Piaget's theory, Robert W. and Cindi Katz interviewed and observed 24 three-to-six-year-old children in regard to their understanding of the hydrologic cycle and reported their findings in "The Hydrologic Cycle and the Wisdom of the Child," Geographical Review, January 1977, the title a twist of Yi-Fu Tuan's "The Hydrologic Cycle and the Wisdom of God" (1979), mentioned in the prologue of our own study. Indeed, the psychologists found that children go to sophisticated (if wildly incorrect) efforts to explain how the source of tap water/

Of the 24, only one volunteered the concept of an underground river.

Child: *Water comes out of the ground.*
Interviewer: *Out of the ground! And how does it get up here [to the faucet] if it comes out of the ground?*
Child: *It's attached to the ground.*
Interviewer: *Ohhh! It's attached to the ground? How is it attached?*
Child: *Under the house it's attached to the ground-in the dirt.*
Interviewer: *And in the dirt is there something for water to come through?*
Child: *And even a river or something.*
Interviewer: *Ohhh.*
Child: *A brook.*
Interviewer: *Is the river or brook near your house?*
Child: *Under it.*
Interviewer: *There's a river under your house?*
Child: *There's a river under every house*.

As only one subject proposed the existence of an actual underground river, we might interpret that such a concept is foreign to most children. But at a more fundamental level, most of the children pictured water in the dirt and water moved by pipes. Linking the ideas would come quite naturally.

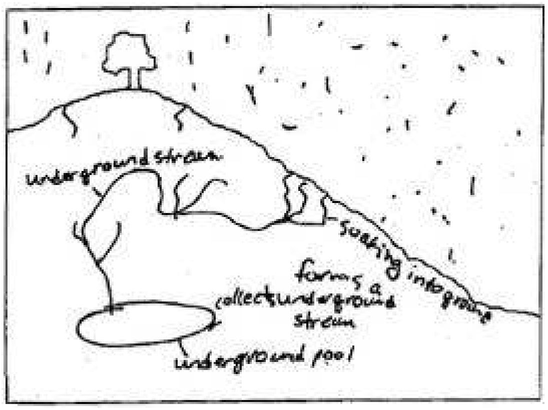
The brain of course doesn't form with an implanted concept of a river underground, and based on the small study above, the explicit idea's often absent through pre-school years. But when the possibility of logical connection presents itself, albeit in a story book of which we've noted many in earlier chapters, the young mind latches on.

After a number of years of schooling, however, children are expected to be better informed. The National Research Council's National Science Education Standards (1996) deemed that eighth graders should possess appropriate understandings regarding groundwater and its role in the hydrologic cycle and textbook publishers have endeavored to incorporate content that adheres to this goal.

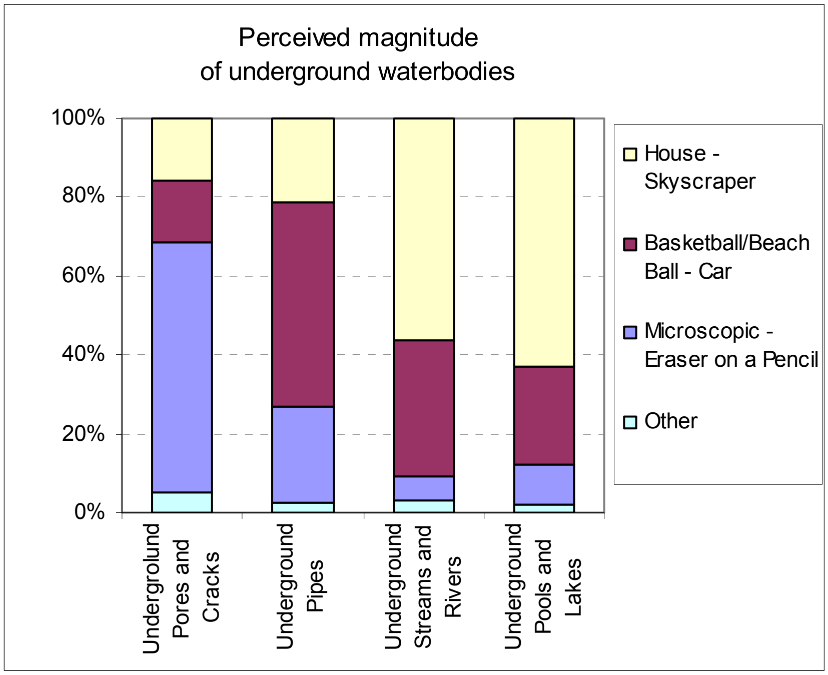
But to how much effect?

The drawing to the right is an illustration from David Dickerson and Karen Dawkins' "Eighth Grade Students' Understanding of Ground Water," Journal of Geoscience Education, 52 (2004) suggests that the National Resource Council goals are yet to be achieved.

In the words of the drawing, "Soaking into ground forms an underground stream," and such streams "collect" to form an "underground pool."



"Students' Conception of Scale Regarding Ground Water," Journal of Geoscience Education, 53 (2005) by David Dickerson, Timothy Callahan, Mary Van Sickel and Genny Hay compared three groups of students but for our purposes we group them into one larger sample. The instrument was a set of multiple choice questions designed to reveal perceptions of magnitude in relation to the four hydrogeologic categories listed on the chart to the tight.



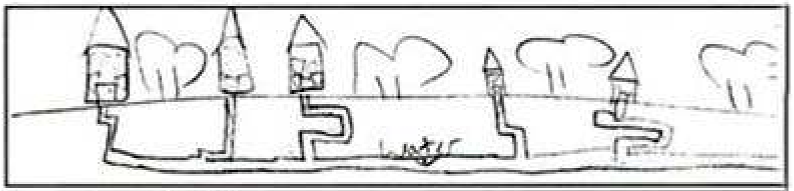
An unsurprising finding is that is that of the first bar. The majority of students perceive "underground pores and cracks" to be in a size range from microscopic to that of a pencil eraser.

Findings disturbing to the National Research Council would be those of bars 3 and 4. A majority of the subjects deem "underground streams and rivers" and "underground pools and lakes" to be between the size of a house and a skyscraper.

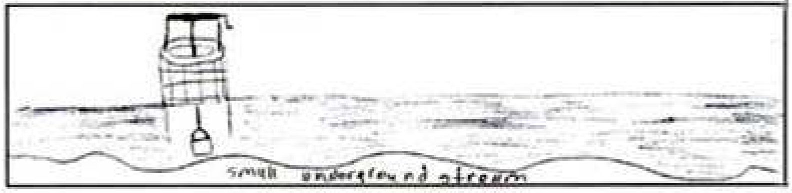
In "Students' Developing Understanding of Water in Environmental Systems," Journal of Environmental Education 40:3, 2009, Beth Covitt, Kristin Gunckel and Charles Anderson asked grade-school children the question, "Draw a picture or explain what it looks like underground where there is water."

Here is a sample of results,

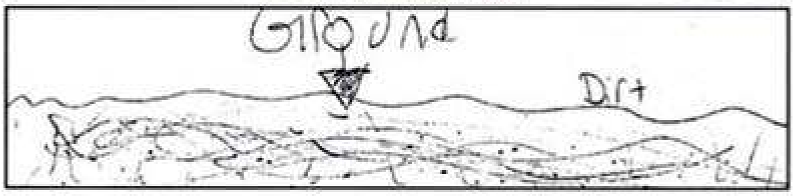
A drawing that that resembles a human-built pipe system,



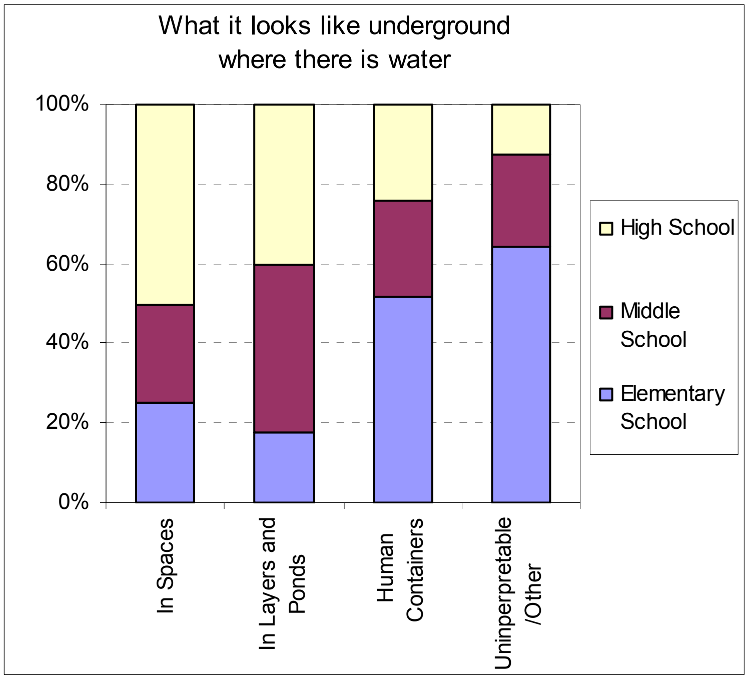
A labeled reference to an underground stream, and lastly,



The concept of an aquifer -- "Dirt," to the student.



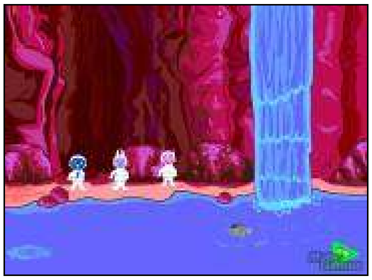
The authors evaluated older students by written survey. The combined results are to the right.



Students at all grade levels more likely envision underground water as lakes and ponds than in small spaces or engineered-appearing tanks or pipes. The positive finding -- slight that it is -- is that by high school, the concept of porous aquifers (i.e., "in spaces") is up to 18 percent. In envisioning what's below our feet, most American schoolchildren still think of flowing streams.

Why don't the children seem to believe what their National Science Education Standardcompliant textbooks tell them?

We looked at numerous underground river games in Chapter 27, but we didn't emphasize how early such game-playing can begin. Here are three aimed at preschoolers.



The Backyardigans, Mission to Mars

Freddi Fish

Pajama Sam

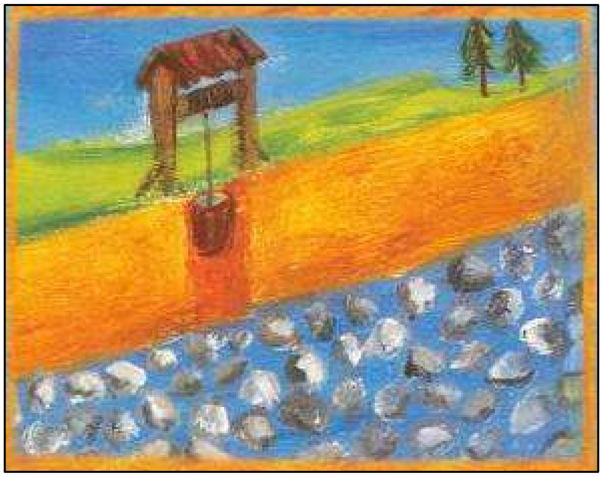
Backyardigans began as a Canadian children's TV series featuring five animal children whose backyard becomes an adventure land. The screenshot shows an underground river on Mars, a geologic possibility discussed in Chapter 41, Underground Rivers in Caverns other than Karst, but the game isn't about planetary science.

Freddi Fish and Pajama Sam are of similar bent. From Freddi's publishers,

> *Kids direct this amazing interactive adventure through a giant tree-house, underground river caverns and even a sunken mine. Teamwork, clever thinking and some creative problem-solving lead our hero, and your kids, to a surprising conclusion -- maybe Darkness isn't as bad as it seems!*

Don't be afraid of the dark, kids, or you'll miss the great underground river and not master creative problem solving. Teamwork is what's important!

We've thumbed through literature that would be read to a young child in Chapter 18, but here we'll note a picture books for young children that's nonfiction.



One Well, The Story of Water on Earth (2007) by Rochelle Strauss is scientifically accurate and up to date. Aquifers are

> *Layers of gravel, porous (holey) rocks or soil that trap large amounts of water.*

Why then, we wonder, does the introduction perpetuate the old-time riverine conceptualization of groundwater?

> *Earth is the only planet with liquid water -- and therefore the only planet that can support life. All water is connected. Every raindrop, lake, underground river and glacier is part of a single global well.*

Put a picture book or a game for small children about a subterranean boat ride in the ring with the National Research Council's goals for eighth-graders. The illustrations win.

American youth have, in fact, been instructed regarding such "underground rivers" for a rather long period. Take the Boys and Girls Magazine Section published by the Los Angeles Herald, March 3, 1907.

Subterranean Rivers

> *It is not an unusual thing in Arizona or New Mexico, or the arid portions of Territories close to the eastern slope of the Rockies, to encounter a stream which, after flowing in the legitimate manner for several miles, will disappear in the panel, sometimes very gradually, at others with startling rapidity.*
>
> *The water simply subsides into the sand, which is very light and porous. Where it goes is another question. Perhaps to feed some vast subterranean lake, or perhaps to emerge again in the form of springs and artesian wells.*

The boys and girls are deceived regarding "some vast subterranean lake," a fairly-common journalistic misrepresentation, but that's minor compared with what's to follow -- an underground river that flows not to, but from, the sea.

> *Sometimes the conditions are reversed, and the river, instead of disappearing before it reaches the sea, comes from the sea and disappears in the land. On the coast of Cephalonia* [an earthquake-prone Ionian island] *the sea runs into the land in a strong stream, turning a water-wheel on its way, and disappears in the earth about one hundred yards from the entrance. These sea-fed rivers are also found in Mexico, where they are known as "zanates."*

"Zanates" are "cenotes," the Mexican sinkholes discussed in Chapter 40.

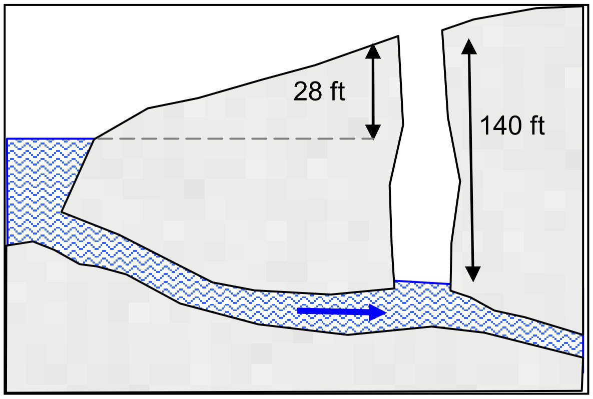
Boys and Girls Monthly Magazine continues onward, blithely plagiarizing a decade-old "Underground Rivers" from the journal Science, April 9, 1886, which we will quote directly.

> *The writer, while passing through Yucatan, Mexico, in 1870, saw a large stream running with torrential speed within a natural tunnel not far from the seashore, and probably over one hundred feet below the surface of the ocean. These underground rivers, which are said to be numerous in the neighborhood of the city of Merida, are called zanates by the inhabitants of Yucatan. I had time to visit only one of these remarkable subterranean rivers. Its shaft-like entrance was adorned by a picturesque old Spanish well-curb of stone, furnished with standards of fancifully forged iron-work. Nothing on the surface indicated the existence of the vast cavern under the monotonous and flat lowlands of the peninsula of Yucatan; and, though not a breath of air stirred, the deafening roar of the torrent under our feet could not be perceived until we were fully inside of the cave.*

The visitor then described his decent into the formation.

> *It had the rounded appearance of a stream flowing horizontally under great pressure, ten or twelve feet in diameter, and looking like a gigantic black icicle lying on its side. This large volume of water plunged with great swiftness into an unexplored and dark chamber with terrific roar, and producing noises which resembled the hollow echoes of heavy explosions heard now and then above the perpetual rumbling of the rushing water.*

> *The manager of the plantation informed me that the mouth or entrance of this zanate was only twenty-eight feet above the Gulf of Mexico; and since my barometer indicated a descent of a hundred and forty feet, if the information was correct, this stream was delivering, within forty miles from the seashore, a volume of fresh water about a hundred and twelve feet below the level of the sea.*



> A river flowing downhill from the ocean! The Boys and Girls Magazine Section seems indeed to have something of interest to more than just boys and girls.

Unfortunately for the boys and girls, however, the rewriter seems not to have read the rest of his source. From the original Science article,

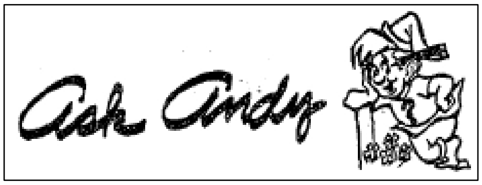
> *This latter circumstance seems to prove that the elevation given by the manager of the plantation may be incorrect; but, besides the fact that the belief in the great depth of these zanates below the ocean is current among the cultivated people of Merida, the manager of the plantation insisted on the correctness of his figures, which were obtained by the instrumental surveys connected with the irrigation of his large estate, the waste water from which runs into the sea.*

To the Science author, the elevation reported by the plantation manager had to have been incorrect, but boys and girls are more likely to read Boys and Girls Monthly Magazine than Science.

Or consider "Underground Streams" in The Youth's Companion, April 15, 1915.

> *Sometimes a farmer stops up the vent hole, in order to make a pond. A man named Johnson once threshed his wheat and stacked the straw in the bottom of a sink hole. Whether he expected this result or not, the drainage hole was stopped up, the water rose until it submerged most of his farm, backed into an adjacent depression, and formed a pond three hundred yards wide, half a mile long, and forty feet deep in places. People came from twenty miles around to fish in Johnson's Pond.*

Of course we can call it just a kids' story, but such "A man named Johnson"-type tales shape pliable minds.



What do they mean by an underground river? asks Larry Roberts, age 8, of Spokane, Washington, in "Ask Andy," Gastonia Gazette, August 8, 1968.

Andy explains it as a "tunnel,

> *We see rivers flowing along on top of the ground outdoors, under the wide open sky. It seems downright impossible for a river to flow under the ground, buried down out of sight. Nevertheless, it is possible. There really are underground rivers. We have found a lot of them and there are many, many more that nobody has discovered. These underground rivers are filled with rainwater that sinks down, down into the spongy rocks below the surface. Some of this water fills the pores and pockets of buried rocks. It collects in vast stores of buried ground water.*

> *But whatever it is, water always must flow downhill. If it is on a slope, it must gush or trickle down to lower land. The buried ground water also must flow downward. Sometimes it collects in tilted rocks buried deep in a hill. Then it must flow down a slope. As it flows it chews and washes out a tunnel for itself through the rocks. This flowing, underground water is an underground river. Sometimes it digs its way to the side of a slope and comes gushing outdoors in a stream or a waterfall. Sometimes it flows on and on for miles underground.*

All in all, the concept of a riverine underground river meshes well with a young mind and for a hundred or so years, we've been infering that the concept is correct.

As Adults

We might grant that children can be easily deceived, but we as, adults, manifest greater power of discernment. The facts, however, seem to speak otherwise.

Ian Maciver, "Urban Water Supply Alternatives, Perception and Choice in the Grand Basin, Ontario," University of Chicago Department of Geography Research Paper No. 126 (1970)

> *Probably groundwater is much more commonly perceived as being stored in underground lakes and flowing in underground rivers, than it is as a resource stored in the pore spaces of rock and unconsolidated sediments.*

As explained by an interviewee in Brantford, Ontario, "Rainfall seeps into the ground and gets into the rocks. Bodies of water are down there -- huge, huge lakes."

Another stated, "There's an underground river flowing northward below Galt that replenishes all the wells in this area. I think it is called the Styx and it empties somewhere into the bottom of Georgian Bay." As noted in Chapter 55, there is indeed a surficial River Styx in the province, but the commentator's mythological perception trumps what's on the modern map.

Of the people willing to express an opinion as to the mode of storage of groundwater, three saw it as occurring in underground rivers, channels, lakes or "veins" for every one who answered correctly.

In "Political Behavior and the Decision Making Process in the Allocation of Water Resources between Recreational and Municipal Use," Natural Resources Journal, 9 (1969), an examination of water management in eastern Massachusetts, Roger Kasperson found that the "giant underground river" was the major myth among Silver Lake residents.

> *The underground river starts in New Hampshire and flows in a curving path through Massachusetts and then empties into the Atlantic Ocean. When it reaches Brockton, it's about 3,000 feet down. The engineers are working on it right now. Where do you think the VA hospital gets its water?*

(We happen to know from Chapter 83, Professor Denton's New England Underground River, that it's not nearly at such depth.)

Five water users and one political official cited of their own volition, this "underground river" as the best possible solution to the problem. Efforts to determine the source of this myth were fruitless, although interpersonal communication was apparently the route of diffusion.

Kasperson's generalizations are straightforward. A "rage for order" impels an individual to put sketchy information into some kind of manageable pattern. A relatively simple, often oversimplified picture is a more efficient way to organize a subject than is a more detailed and confusing picture offered by scientific experts.

For the ordinary citizen not directly concerned with groundwater management, equating underground conditions and the surface rivers and lakes with which he or she is familiar is a simple and efficient way to organize an otherwise-confusing set of phenomena.

Metaphor, the extension of the principles and patterns of a familiar field to a less familiar one, is an efficient way to gain a sense of understanding. An individual's tentative picture of subsurface processes will be reinforced every time he or she encounters a reference to "reservoirs," "basins," or "flow," or sees the collapse of a cavernous Florida limestone sinkhole.

Kasperson's answer is not to promote details of the subsurface environment or the equations of groundwater flow. More realistic and efficacious education might come from metaphors according better with relevant facts and less well with the surface realm. Develop terminology not suggesting a correspondence between the features of subaerial and subterranean "reservoirs," "basins," and "flow."

In "Vernacular American Theories of Earth Science," Journal of Geological Education, 35 (1987), William Meyer notes that as everyman is his own historian, everyman is his own earth scientist. Those who have no instruction in the subject do not dismiss it from their minds, but rather construct pictures of the earth and its processes with the tools available. They then act on the basis of the beliefs, correct or incorrect.

Meyer reflects on notion of wide currency in American thought, past and present, that groundwater occurs in much the same form as does surface water -- in large .basins or lakes and in rapidly flowing streams, rather than in the interstices of sediment and bedrock. Meyer notes the use of such words as "pools," "lakes," "rivers," "streams," and "veins" as descriptors rather than metaphors, usually implying the idea of groundwater as a contiguous body.

The over-riding thesis of those in the profession of educational psychology returns us to the discussion of models in the introduction of our own study.

Models are expressions of something we think we'd like to understand in terms of something we think we do understand.

In the words of Mciver,

> *One's conceptions of the unknown tend to pattern themselves after the known and since surface waters congregate into wide bodies such as lakes or confined routes such as rivers; this thought pattern may be transferred to the subterranean world.*

At almost every turn of our journey, we've quoted portions of what readers of a given era would themselves have read. The telling of the story is itself part of the story.

We should acknowledge our propensity attribute notable attributes to lands having revered history. Take, for example, "A New Winter Resort," Living Age, March 17, 1883, a travelogue of 19th-century Palestine.

> *One of the fellahin, seeing my interest in ruins and topographical curiosities, led me to the head of a valley, where he said there was a mysterious rock with a hole in it, where the roaring of a mighty river might be heard. The aperture was a crack in the table-rock of limestone, about three inches, by two; its sides were worn smooth by listeners who had placed their ears upon it from time immemorial. On following the example of the thousands who had probably preceded me, I was saluted by a strong draught of air, which rushed upwards from unknown depths, and heard to my surprise, the mighty roaring-sound that had given the rock its mystical reputation; but I felt at once that no subterranean river large enough to produce the rushing of such a torrent, was likely, for physical reasons, to exist in that locality, for the noise, is that of a distant Niagara. I was puzzled till I ascended a neighboring hill, where the roar of the sea was distinctly audible; and I am therefore disposed to think that the fissure must have led to a cave on the seashore, from which the sound is conducted, as by a whispering gallery, to this point, distant from it about three miles.*

The media subscribes to our need for stories, even the New York Times. Take, for example, an April 15, 1928, feature article.

> *Underground Rivers are Found to Originate in Three Ways*
>
> *One of nature's oddities is the underground river, many of which have been found beneath the United States. Streams under the earth's surface arise in three different ways. One of them is by water seeping through limestone rock and running under the surface, to emerge some*

> *distance away. Charles P. Berkey, Professor of Geology and Mineralogy at Columbia University says that "the underground waters move through the fractures and joints of the rock and gradually dissolve some of it, making in this way more and more room for the flowing water. This kind of action forms caves, many of which are extensive indeed."*
>
> *In many limestone regions small streams developed on the surface have disappeared into the ground. Subterranean rivers are also formed in sandy and gravel districts, the river sinking through the sand and gravel to reappear further away.*
>
> *The third way in which underground rivers take form, according to Julian D. Sears of the United Slates Geological Survey, is disclosed in districts where large areas have been submerged by lava which is likely to break up on cooling in such a way as to be very permeable. In some of the lava-covered areas the water sinks as rapidly as it does in limestone and tends to follow the pre-existing streamways and eventually to emerge in large springs. Underground streams of this type are found in Idaho, Oregon and California.*
>
> *These rivers are often traced by following' sinkholes-depressions shaped like saucers with holes in the bottom. Sometimes underground rivers wear away the earth and rock above them and make their subterranean courses visible. They may be traced when invisible by putting coloring matter in them, uranin dye being adapted to the purpose. Last year, in Manchester, England, an underground river traced in this way was found to be more than eight miles long.*

What Prof. Berkey states is entirely true -- subterranean waters flow in one of three ways:
As percolating groundwater,
Via karst passageways and
In volcanic tubes.

Geologists of 1928 knew their geology. What misleads us is the professor's order presentation and degree of pursuit. Seeping rivers are "also formed in sandy and gravel districts." Nearly all of us who drink well water, public or domestic, draw from this "also," but here the subject is given the pazazz of grainy dirt.

The New York Times instead plays for the dramatic. "Caves, many of which are extensive," "pre-existing streamways," "uranin dye" (a florescent yellow-green chemical that sounds vaguely radioactive) and "eight miles" are phrases we remember. Arkansas contains at least three Blue Lakes, one in karst uplands and two in abandoned Mississippi meanders, but this blue lake appears to sport hydrogeologic characteristics of both terrains. No matter the confusion, what the reader's mind is wired for is the Mississippi's "ebb and flow."

Why would the reader not come away believing all the more in rivers rushing underground if it's in the New York Times?

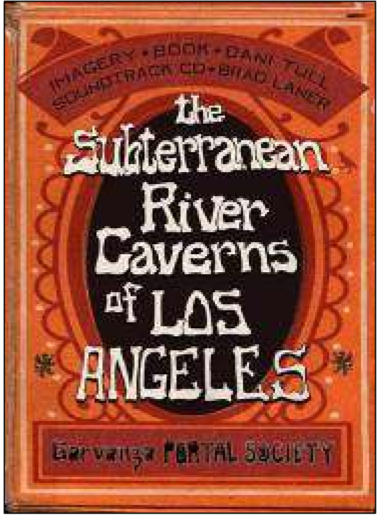
Who among us doesn't want to believe a good yarn? Take, for example, "Subterranean Streams in South Carolina," Popular Science Monthly, June 1876,

> *The next spring of which I know the existence is at "The Rocks" plantation, some twelve miles away, and the last of the chain is the famous "Eutaw Springs," where a battle was fought during the Revolution. At the latter place there are two openings, some distance apart, and tradition says that an Indian once dived into one and emerged from the other... The indications seem to be that this enormous subterranean cave or water-course is hollowed out through a narrow stratum of limestone-rock which winds its way in a southeasterly direction; but it may be of far greater extent. Near Pineville, some ten miles from the nearest spring, and considerably off the course, there is a certain spot in the public road where the sound of the horse's feet is precisely like the noise made in crossing an earth-covered bridge, and tradition tells of treasure buried there in Revolutionary times.*

A Revolutionary battle! The Indian! The horses' hollow hoof beats! Buried treasure! This underground river has it all.

Who among us doesn't want to believe in something wonderful? Take, for example, "The Helderbergs," Harper's New Monthly Magazine, October 1869, a report of a limestone escarpment in New York State.

> *Cave explorations are interesting to those who love to see the wonder of nature -- things before unseen, new and surprising. Who knows, someone thus exploring may discover a great, subterranean transcontinental river; an underground, round-the-world canal, cheapening freightage between New York and San Francisco. Whether you should find this wondrous stream or not, a visit to the under-world will not be forgotten; the hornstone and the fossils collected, nay, the grimy, shattered lantern that you carried, will ever remain objects of interest.*


IMAGERY • BOOK • DANI TULL
SOUNDTRACK CD • BRAD LANER
the Subterranean River Caverns of LOS ANGELES
Garvanza PORTAL SOCIETY

In The Subterranean River Caverns of Los Angeles (2006), Dani Tull chronicles his invented-reality explorations into the secret network of caverns below the urban surface -- not secret to us however, as we were there in Chapter 88, Extraterrestrials and Lost Rivers of the American West.

An accompanying soundtrack provides a sound track of the imagined sounds, the audio fascination noted in Chapter 36.

Many Angelinos believed Tull's maps to be real and searched for the "portals" marked with an X, a fitting real-world culmination of constructed mythology.

Why do we believe what we believe?

We always hope to find something.

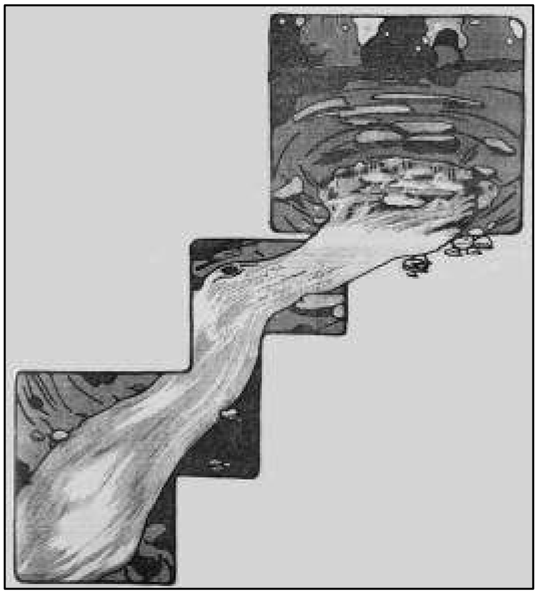
Add to our natural inclination to believe in underground rivers the fact that we, as a literate culture, have been long primed with misinformation.

Brooklyn Daily Eagle, June 5, 1872	New York Herald, February 16, 1877
Miscellaneous Items	Personal Intelligence
The mortal remains of 117 steamboats adorn the bottom of the Arkansas River.	*Iberia, La. has a white negro with white hair.*
A natural spring that will intoxicate, situated near Kern River, Cal., is delighting the Indians of that vieinity.	*It is believed that the Jura Mountains of Switzerland are undermined by subterranean streams.*
Those best acquainted with the topography of the Colorado desert are confident that a large subterranean stream runs under it, and that the entire desert may be reclaimed by artesian wells.	*England is getting salmon eggs for her rivers from the Rhine and expects to make even the Thames a fine fishing place.*

Minneapolis Journal, August 24, 1901 The World for a Week *Probably the most valuable street crossing in the country is one at Manhattan, Kan. which consists of flat stone slabs bearing petrified footprints of prehistoric birds. They were collected by a geological student, attached for freight duties and finally taken by the town marshal to repair the crossing.* *A mighty subterranean stream has been found in Ohio in the vicinity of Chardon, a suburb of Cleveland. Wells have been dug which at a certain depth began to roar. In one of these the bottom dropped out, revealing a stream which was so swift it could not be sounded.*	Salt Lake Telegram, January 9, 1925 Interesting Facts *An underground river is believed to pass beneath France.* *Luminous gloves are being worn by Parisian motorists.* *The "military pace" is reckoned at two feet, six inches.* *Ants can swim, using their six legs like a six-oared boat.* *Women are in charge of one of London's largest animal hospitals.*
Salt Lake Telegram, April 9, 1927 Facts of Interest *An old Irish legend of about 944 A.D. gives an account of a vision of a ship or airplane in the sky.* *An underground river has been discovered passing under Mount Blanc, the highest mountain in the world.* *Traffic congestion on highways and streets of the United States is responsible for an annual loss of four billion dollars in time and wasted fuel.*	Science News-Letter, January 9, 1928 *A recent study of college students shows that one of the chief causes of failure in college is inability to read.* *The course of an underground stream in England was traced for eight miles by placing coloring matter in the water where an opening occurred.* *A duck hospital for ailing ducks was established recently by California's fish and game department.*

Impress your dinner-table companions with such bits of knowledge.

Indiana's Lost River provides us an opportunity to note the bane of journalistic misfeasance associated with subterranean watercourses.



The text of "The Mystery of the Far-Famed Indiana River Which Loses Itself," Saint Paul Globe, July 25, 1902, is wrapped around the graphic to the right. We will peruse the article for journalistic assertions common to underground river stories.

> *For years geologists and other men of science have sought an explanation to the mysteries of Lost River, but today the remarkable stream is almost as great a mystery as ever.*
>
> *The only explanation that can be accepted as the true cause of the strange pranks of Lost River is the fact that this entire underground section of Indiana is hollow -- literally honeycombed. In fact, with caves and caverns into which Lost River plunges, only to suddenly reappear again in some unexpected place.*
>
> *The theory had been advanced, in fact, it is now known almost beyond a doubt, that the subterranean passages through which Lost River flows, and that the numerous caves in the vicinity of the stream, are but a part of the system of caverns branching off from the Mammoth cave of Kentucky. In proof of this claim, the same varieties of blind fish have been found in Lost River which swim the gloomy river Styx of the mammoth Kentucky cave.*
>
> *Near Orleans, Lost River drops from sight into a great dark cavernous hole, which has the appearance of the entrance to Satanic regions -- and from which the river gains its secondary name -- the river Styx.*
>
> *Lost River boils up from the bowels of the earth like a mammoth spring, and flows away a stream thirty or forty yards in width. The river entirely fills the cave from which it bursts forth, even in the driest seasons. Here the river forms an immense pool, the depth of which is unknown. Boats have been rowed over the boiling surface of the water and lines with lead weights attached have been let out for over 860 feet, but no bottom was torched. The stream has the appearance of a huge spring as the waters boll and swirl up in three great bubbles from unknown depths below.*
>
> *Half a mile north of Orangeville is a spot known as the gulf. It is a great deep funnel-shaped valley, the bottom of which the waters of Lost River again rise and flow above the surface in a serpentine course for about fifty yards. Then the river rushes into a fissure in the rocks and hides underground again. For many years it was thought these were the same waters that appear at Orangeville, but sawdust and oats cast in the waters at the gulf have always failed to appear at the rise far below.*
>
> *The Widow Scott, who lives four miles from Orangeville, was in the habit of keeping her milk in the mouth of a cave near the rear of the house, which was cold and well adapted to the purpose. For crock covers she used the large square tops from tobacco boxes.*
>
> *One morning the widow visited her milk house and was surprised and perplexed to find its floor swept clean. Not a vestige of crocks, covers or milk was to be seen. A heavy rain had come up the night before and, running into the cave, had carried away the widow's milk crock covers. The next day, however, they were found floating peaceably in the river near the old Springer chapel, over three miles from their accustomed place, and none the worse for the subterranean journey.*

Standard journalistic misrepresentations:

Reference to a hollow earth, the theme of Chapter 14, Hollow Earth Geophysics. "This entire underground section of Indiana is hollow," paints a picture more dramatic than, say, "This entire underground section of Indiana contains many caves."

A link to Mammoth Cave. Mammoth Cave is 200 kilometers distant and has a karst drainage area of roughly 20 by 20 kilometers. There is no link to this Lost River, though as noted in Chapter 50, Mammoth Cave connects to another Lost River.

Like fish as proof of connection. As noted in Chapter 47, Wrecks of Ancient Life, eyeless fish are indigenous to many cave systems in the region.

The Styx comparison, the familiar literary allusion pursued in Chapter 55, A Superfluity of Surface Stygian Streams.

The pit of "depth unknown." The weight didn't fall vertically; it was likely carried downstream.

The error of a false negative, in this case that not recovering sawdust and oats disproved hydraulic connection to a nearby spring.

The personal tale of an unfortunate, a readership favorite. That Widow Scott's milk crock covers could have been washed downstream by overland streamflow eluded the reporter.

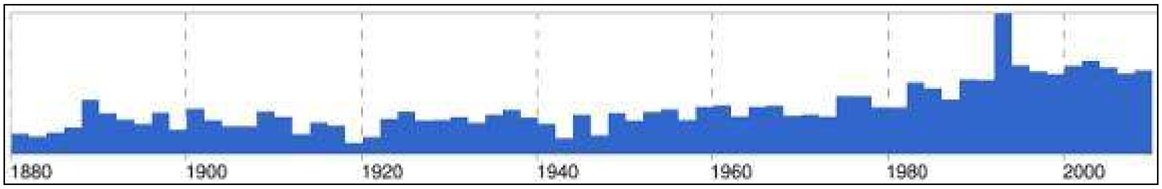
The Globe's account added little to public edification, but it did well in enhancing popular misconceptions.

And it's not just an issue of elementary education. From "New Machine Sparks Rivalries at CERN," Science, June 16, 1989, an update on the 100-GeV Large Electron-Proton Collider; European Laboratory for Particle Physics in Geneva,

> *The construction of the accelerator, too, which is buried underground at depths ranging from 50 to 170 meters, and extends from the plain next to Lake Geneva right up to the edge of the Jura Mountains, has had its headaches. To meet opposition from local residents, all the electric cabling had to be buried in trenches. And digging was halted for several months in late 1986 after construction crews unexpectedly came across an underground river.*

If today's prime scientific publication refers to an "underground river," how can we disagree?

Here's a timeline of news articles with "underground river" in the title. The raw numbers are not particularly meaningful, as they are proportional to the breadth of the database, but the increase over time itself tells a story. The relative rash over the last several decades was spurred by discoveries in karst regions. The spurt in 1992 was driven by the shenanigans of the Texas Water Commission (Chapter 63, The Law of Subterranean Streams).



We've spent more than 50 chapters looking at the topic through a variety of perspectives. Had we input from experts in other fields, say health science, we'd have had even more chapters -- and we invite such input -- but we don't need additional vantage points to recognize the commonality.

We persist in envisioning underground rivers because we're inundated with such references.

Why do we believe what we believe?

As children and as adult -- it seems to make little difference -- wqe're wired to envison underground rivers and what we're told so often misleadingly reinforces the concept.

Looking at the journey we're now completing, was it not the dramatic portrayals that best caught our fancy?

In Chapter 15, The Maelstrom, we reflected on human fascination with the might of nature.

In Chapter 84, Underground Rivers of Gold, we noted how the precious metal commands our attention.

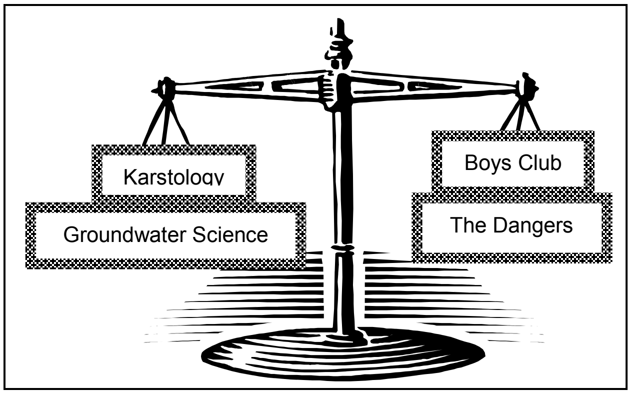
In Chapter 88, Extraterrestrials and Lost Races of the American West, we observed how outlandish tales engage our imagination

Stories of underground waters tend to be more engaging than the facts behind them.

Let us test our own propensity.

Select two or three chapters from out study that presented an aray of solid facts and meaty quotes. Choose another two or three that dealt more with stories. A pair of each type of chapter is illustrated at the right. We're going to weigh our reactions.

Which chapters did we find more engaging? Which contained items we yet remember? Which chapters might we want to revisit?



Our journey's made us better informed regarding karstology, but it's the segments dealing with stories, the ones on the right arm, that better registered. We factually know that underground rivers comprise but a minute portion of the world's water resources, but at the same time, such waterways retain a big place in our consciousness.

CONCLUSION

Surely we've yet missed much on our subterranean journey, but we've seen perhaps more than we thought we'd encounter.

We've seen Charon at the oars, reminding us that from days long before Homer, subterranean streams have linked us with the afterlife.

We've seen how Judeo-Christianity, a centerpiece of Western culture for the last 2000 years, appropriated Greek concepts of natural philosophy, and in particular, how unseen underground rivers fit into the earth's scheme.

We've seen how burgeoning science strove to explain the mechanism by which water returned from the sea to the springheads. We've seen how theological preconceptions delayed the process and at one time, how what little knowledge had been garnered was preserved.

We've seen some strange physics and we're seen what we not believe to be the correct understanding.

We've seen the wholesale incorporation of underground river lore into fiction, some of literary merit, some at best suited for adolescent boys.

We've seen what poets and artists have done with underground rivers.

We've seen a good bit of geology and a bit of biology.

We've seen how we've made use of subterranean waters. We've seen the dangers in doing so.

We've seen that the Rio San Bonaventura may be flowing under our feet.

We paddle in Charon's wake

.

FINAL EXAM
DAY TRIPS FROM MONTICELLO

This final examination isn't for a grade. If we've made it this far, we most certainly have earned the credit/

Rather, let us test the validity of the basic hypothesis suggested at the start of our journey -- that underground rivers are woven into the fabric of our being. In one sense or another, we're never far from one.

In the previous chapters, we've cited "Monticello" locations multiple times. It's an historic name -- the Virginia residence of Thomas Jefferson -- and an atlas reveals no less than 20 American towns, lakes or dams by that name.

We'll engage in a quick exercise -- nothing scientific or rigorous, we admit, but enough to see if our hypothesis is justified.

Is there an underground river within a day trip from each Monticello?

Our constraints:

We'll use only information from the previous chapters.
We'll allow "underground river" any of its meanings.
We'll define "day trip" as within the same state.

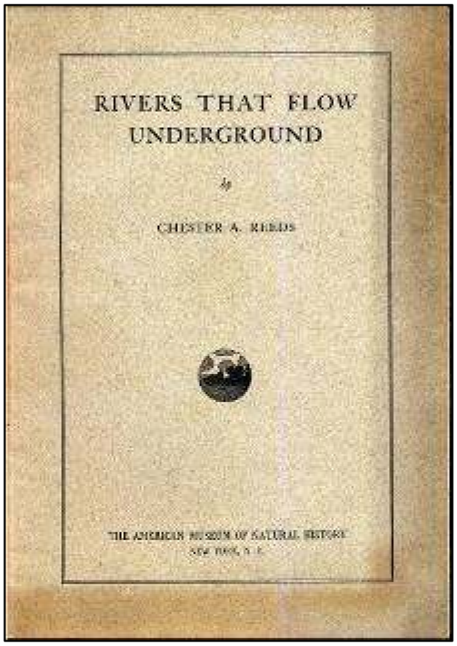
Here's where our day trips might lead us.

From	To -- km	To Visit	Chapter
Monticello, AR	Harrison, AR -- 370	Hurricane River Cave's artificial waterfall	52
Monticello, Dam CA	Monticello Dam, CA -- 0	The maelstrom	59
Monticello, FL	Wakulla, FL -- 70	Wakulla Springs. Dive with care.	52
Monticello, GA	Cave Spring, GA -- 230	Good water	68

Monticello, IL	Monticello, IL -- 0	"After digging down 65 feet and boring 22 feet he came to a body of water, which burst forth with a rushing current and rose 50 feet in thirty minutes."	74
Monticello, IN	Bedford, IN -- 260	Bluespring Cavern's 4.8 kilometer boat ride	52
Monticello, IA	Monticello, IA -- 0	Hometown of Old Jumbo's diviner	39
Monticello, KY	Mammoth Cavern, KY -- 150	There's nothing like Mammoth.	50
Monticello, LA	Delcambre, LA -- 410	Lake Peigneur. Drill with care.	68
Monticello, ME	Eagle Lake, ME -- 130	Home of the 19th-century Yankee who in response ton fanciful theories of lakes fed by underground rivers, judged, "Well, I guess it rains in."	46
Monticello, MN	Harmony, NM -- 270	Is Niagara Cave connected to the other Niagara?	78
Monticello, MS	Natchez, MS -- 130	"Hurrying toward the subterranean stream, were other streams, small and great, but all deep, hurrying to and from that great mother-stream underneath, just as the small and great overground streams hurry to and from the mother Mississippi."	79
Monticello, MO	Hannibal, MO -- 75	Mark Twain Cave	16
Monticello, NY	Monticello, NY -- 0	Where the Monticello and Port Jervis Railroad encountered the incrusted lake	74
Monticello, NC	Whiteville, NC -- 290	"When in the vicinity of the supposed stream it can be plainly heard, but when a person lies flat upon the ground the phenomenon becomes really alarming."	39
Monticello, TX	Austin, TX -- 500 Ft. Worth, TX -- 230	"Render unto Caesar that which is Caesar's" -- Texan law of subterranean streams "and unto God that which is God's" -- God is a Great Underground River	63 29
Monticello, SC	Prineville, NC -- 210	"There is a certain spot in the public road where the sound of the horse's feet is precisely like the noise made in crossing an earth-covered bridge, and tradition tells of treasure buried there in Revolutionary times."	89
Monticello, UT	Cedar City, UT -- 550	Cascade Falls, where lava abuts karst	41
Monticello, VA	Natural Bridge, VA -- 130	Once owned by Thomas Jefferson	39
Monticello, WI	Spring Valley, WI -- 241	Crystal Cave's artificial pools and carpeted walkway	52

Twenty out of 20 Monticellos are each in some way near an underground river. Most city names won't score as well, but the count seems to confirm our hypothesis -- We are never distant from such waters.

POSTSCRIPT



Subsequent to posting an earlly draft of this document, I came upon a reference to Chester Albert Reeds' Rivers that Flow Underground (1928), published by the American Museum of Natural History. Of the academic libraries having linked catalogs, the item's held by only Johns Hopkins, the American Museum of Natural History, Case Western and the University of Oklahoma.

But given the title, I had no choice but to pursue the document. Reeds turns out to have been the museum's Curator of Geology and Invertebrate Paleontology and his work -- one of many, as he was a tireless publicist for natrual science -- is a 16-page booklet inspired by an Explorers Club outing to Virginia's Endless Caverns. Illustrated with 16 photos and a map, Rivers that Flow Underground was written for the curious public.

Endless
Caverns
$16.00

In researching my book, Endless Caverns hadn't risen to my attention as it offers little unique regarding karstology or hydrology, and in fact, hasn't even a boat ride. It's just another Shenandoah Valley excursion for Washingtonians. The advertised "55 degrees year 'round" sounds inviting on a muggy summer day, but $16.00 seems pricey for just a stroll.

As with many American cave attractions, Endless Caverns' better days were in past decades.

Underground River

Historic postcard

But in 1928, the caverns were very much an adventure for Chester Reeds.

> *By means of a rope, the party wound its way down over slippery walls to the clear stream at the bottom. Here the water was cool and shallow, and the ceilings so close at times that we were obliged to stoop. In some places the ceiling was as low as eighteen inches, and the only way we could precede was to lie flat in the rushing water and squirm along. Then we would come out into fairly large chambers where we could stand up and stretch. It took one and one-half hours to cover two hundred yards in this manner. Progress upstream was stopped by the ceiling descending abruptly into a deep pool of water. It may have been possible to dive under*

> *this obstruction, but it was not deemed wise to attempt it before exploring a side avenue. But this was blocked by a growth of huge stalactites and stalagmites, and, after noting raccoon tracks in the red mud, 'we essayed to return to the point of entry and to proceed downstream in an endeavor to find the outlet. This part of the trip was more interesting, for the chambers were larger and the ceilings were not so low. The red mud, however, was more plentiful and the sloping shelves more treacherous. Twice we reached places where it was impossible to follow the actual stream bed, but in both instances we found passages above which led to the water beyond. After much scrambling we came to a "Fairy Fount," to a perfect likeness of an "Elephant's Head," and to a "Silent 'Waterfall," over which the stream dropped some ten feet. Having left our ropes dangling at the point of entry, we could not proceed farther, so we placed the following label in a bottle and turned back:*
>
> *This bottle is placed at the farthest point penetrated by members of the expedition of the American Museum of Natural History and the Explorers' Club of New York, May 1925. If anyone finds it and can carry it still farther, please report to the American Museum of Natural History.*

To establish the existence of underground rivers, Reeds cites ancient Greece, the karst regions of Europe, Mammoth Caves and even lava tubes. Much like this book, actually.

That all but one of Reeds' examples were known to me is of no matter. Nor are his occasional errors, e.g.,

> *The swiftly moving, acidulated waters have carved many a tortuous tunnel and left behind many a spacious chamber.* -- "Subterranean Streams of the Endless Caverns, Virginia," Bulletin of the Geological Society of America 37:1, 1926

What's of matter is that century before me, someone was on the stream that I'm yet traveling.

While it seems non-sequitur to credit in postscript a source not known to me at the time of my compilation, I'll do so none the less.

In the Tradition of
Chester A. Reeds,
Curator of Geology and Invertebrate Paleontology,
American Museum of Natural History

As written in the Explorers Club bottle,

> *If anyone finds it and can carry it still farther, please report to the American Museum of Natural History.*

I indeed found the bottle.